KEYSTONE

THE MINING CATALOG

CONSOLIDATED PUBLISHING COMPANY INC.

1922

METAL-QUARRY

EDITION

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THE MINING CATALOG

(METAL AND QUARRY EDITION)

Second Issue (1922)

A Consolidation of Condensed Catalog Information Pertaining to the Metallic and Non-Metallic Mining Industries, Quarries and Cement Mills

TOGETHER WITH

ENGINEERING DATA COVERING THE VARIOUS OPERATIONS PERTAINING THERETO

DEVISED, COMPILED, EDITED AND PUBLISHED BY

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Introduction

IN offering the second issue of the MINING CATALOG for your approval we are glad to announce the vindication of our sanguine hopes for the success of the first edition. Again we ask the support and cooperation of the officials of the Mining and Quarrying Industry in making it the power that it should be.

The MINING CATALOG, Metal Edition, is, in keeping with the established policy of its publishers, a larger and better book. Thanks to the kindly suggestions and friendly criticisms of the first issue it has been possible to carry on our work in a manner pleasing to ourselves and, we hope, to you.

The MINING CATALOG is one of a large and increasingly important class of publications known as the Catalog Group. Its function is to act as a source of information for the use of business men, executives and engineers, who seek, not display advertisements, which are available in the current periodicals for which they are eminently suited, but catalog information to be used immediately for business purposes. It is in no sense designed for the casual reader, but for the reader of serious mind; for the man who buys and the man who sells.

We ask the mining man to remember that the companies represented in the MINING CATALOG, Metal-Quarry Edition, furnish its entire financial support, and that they alone make possible its free distribution. It is their desire as well as ours that this book shall reach every responsible man in the Mining and Quarrying industries. They wish to know what form of publicity brings the best results. We want assurance that the MINING CATALOG is performing its proper function. We ask, therefore, that this publication be given full credit for every inquiry arising from it. Simply say you saw it in the MINING CATALOG, Metal-Quarry Edition.

The MINING CATALOG should reach the scene of operations of every mine, quarry, mill and smeltery in the United States and Canada; and it is our intention that it shall find its way to every important concern in Mexico, Central and South America, Europe, Asia, Africa and Australia where there are English reading operating officials. It is sent free to each company on record in our offices, to colleges, universities and technical schools where mining engineering is taught, to consulting mining and metallurgical engineers and to each concern represented in the catalog pages of this book. To all others the price of the MINING CATALOG is Ten Dollars. Special prices are quoted to students of engineering schools and to organizations pursuing courses of study at mines.

The KEYSTONE DIRECTORY OF METAL MINES AND QUARRIES will in the future be our guide in the distribution of the MINING CATALOG. Questionaires are sent to all companies on record in our office. These questionaires ask for tabulated information regarding your company's personnel and the nature of the equipment used at your mine and in your treatment plants. An immediate and full response to this questionaire is the only unfailing means of insuring the receipt of future issues of the MINING CATALOG.

KEYSTONE CONSOLIDATED PUBLISHING COMPANY,

Joseph J. Vigneau, President.
E. B. Day, Vice Pres. and Eastern Manager.
Ralph C. Becker, Vice Pres. and Western Manager.
E. N. Zern, Mining Engineer and Editor.

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EDITOR'S PAGE

It has been my privilege and pleasure to have a small part in the training of a unique group of young men. They are, let us say, the symbol of a new "get back to school" movement in the coal mining districts of Pennsylvania. It seems odd to us metal miners that the group of mine operators whose ranks probably contain the smallest proportion of educated men should be the first to realize the absolute necessity of a higher education for the coming generation of miners. These operators, representing about ninety per cent of the tonnage of the Pittsburgh district, form the advisory board of the "Co-operative Department of Mining"of a nationally known technical school located in Pittsburgh. Each year about twenty men are picked from the "rank and file" of the mining organizations, their qualifications consisting of two years experience in or about the mines and a desire to succeed in their chosen work. In most cases their employers are directly interested, lending their moral and, if necessary, their financial support to help the boys through their two years of intensive training. The results have been a startling revelation to those who have been fortunate in having a hand in this educational experiment.

I have no intention of drawing odius comparisons between our branch of the mining profession and the phase dealing with coal production. My object is merely to direct your attention to the young fellow who is helping your assayer, chaining for your engineer, "herding tables" in your concentrator; he may be running a motor or a drill; his guiding star may be a shift bosses' berth when it might as well be a superintendent's.

Here logically comes my point. If you cannot give him an educational boost, at least give him your last year's MINING CATALOG when you receive this issue. Put it where he can use it in his work not only for his own instruction but for your profit.

Those who received the first issue of the MINING CATALOG will remember that we asked you to criticize it. We wish to make this request more emphatic; to impress upon you the fact that we live and thrive on criticism, for by criticism only may we know when and how we fall short of the standard we set. We shall be disappointed this year if we do not receive, not commendation only, but honest, helpful criticism of both matter and form. We want you to take time to go through the book from cover to cover with this in mind.

Changes have been made to conform to suggestions and to make the book more valuable to the majority of its users. The sections have been arranged in a more logical order. Some articles have given way to matter which, in the opinion of the editors, will be of more practical value. The most radical change is in the indexing. The sections have been numbered and the Index of Sections has been placed inside the front cover of the book. Facing this page is another Index showing alphabetically all general classes of machinery indicated in the section titles. No claim of originality is made for this feature. It may be found in Mark's Mechanical Engineer's Handbook and Peele's Mining Engineer's Handbook. This arrangement will be particularly pleasing to those accustomed to using these two well known reference works. Do you like the idea? Tell us if you do or do not.

W. L. REMICK, Associate Editor.

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Index of Products

The **PRODUCTS INDEX** serves the user of this book by making it possible easily to locate the sources of supply. For the convenience of information seekers all the items which appear on the catalog pages are listed alphabetically, and beneath each is given the name of the company capable of supplying the article, together with the page number or numbers on which mention of it may be found.

Because the **PRODUCTS INDEX** conserves time, this section is undoubtedly referred to oftener than any other in the book. In order to assist in its ready location it has been printed on tinted paper.

An innovation this year, which we believe will be heartily approved, is the method of listing firms under each item in such manner that it is possible to distinguish articles or devices which are illustrated or described from those which are merely mentioned on the catalog pages of the manufacturer or dealer. Our method of accomplishing this is to put in **black face type** the names of all firms that describe or illustrate an article, and in light face type those firms that merely list the article as available, but without illustration or description.

In the great majority of cases the article will be found listed under the noun. For example, when looking up jaw crushers, look under the heading CRUSHERS—Jaw; when you want a list of makers of mine car wheels refer to WHEELS—Mine Car. In a few cases we have permitted usage to govern, thus dealers in brattice cloth will be found listed in accordance with common usage, that is under BRATTICE CLOTH.

After noting the names of concerns and their page numbers, reference should be made to each page for further information on the article. Many of the catalog page headings contain a list of Branch Offices, Agencies and Distributors for the firm products. This will be found helpful when writing for prices and delivery, or where quick shipment is essential.

The **PRODUCTS INDEX** is a time saver—USE IT.

And after using it, don't forget to say, **"I saw it in the MINING CATALOG."**

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DUMPERS—Railroad Car
Car-Dumper & Equipment Co.410, 411
Robins Conveying Belt Co.....658
Weller Mfg. Co.....660, 661

DUMP PLATES—For Skips
Lake Shore Engine Works.....415

DUMPS—Cross-Over and Kickback
Card, C. S. Iron Works Co.....371
Webster Mfg. Co.....659

DUMPS—Rotary (Mine Car)
Car-Dumper & Equipment Co.410, 411
Lake Shore Engine Works.....415
Pittsburgh Mining Machinery Co..810
Wellman-Seaver-Morgan Co.....409

DUMPS—Rotary (Quarry Cars)
Car-Dumper & Equipment Co.410, 411

DUST COLLECTORS
Allis-Chalmers Mfg. Co.....491
Stroud, E. H. & Co.....742

DUST PROTECTORS
(See Respirators)

DYNAMITE
(See also Explosives)
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....556, 557
General Explosives Co.....559
Giant Powder Co., Con., The....560
Grasselli Powder Co.....561
Hercules Powder Co.....562
Illinois Powder Mfg. Co.....564
Salt Lake Hardware Co....277, 821

DYNAMOS
(See Motors and Generators)

EARS—Trolley
(See Clamps, Trolley)

ECONOMIZERS—Fuel
Sturtevant, B. F. Company.....161

EJECTORS
Worthington Pump and Machinery Corp.....165, 166

ELBOWS—Lead Lined
United Lead Co.....710, 711

ELECTRIC ARC WELDING
(See Welding and Cutting Apparatus, Electric Arc)

ELECTRICAL REPAIRS
(See Repairs—Electrical)

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ELECTRICAL SUPPLIES

(Items embraced in this classification are listed below the names of firms)

Colonial Supply Co.....831, 832
Davidson, O. H. Equipment Co...354
General Electric Co.....241, 242, 246, 247, 331
Mine and Smelter Supply Co....632
Salt Lake Hardware Co., The..277, 821
Westinghouse Elec. & Mfg. Co...249, 250, 252, 255, 256, 257

Adapters
Adjusters, Cord
Ammeters
Anchors—All Kinds
Armatures
Arresters, Lightning
Asbestos Material
Bars, Bus—Copper
Batteries—All Kinds
Battery Supplies—All Kinds
Bells, Electric—All Kinds
Belts, Linemen's
Bends, Conduit—Fiber
Blocks, Fuse—All Kinds
Blow Torches
Boards, Panel
Bolts—
  Expansion
  Eye
  Insulated, Trolley
  Suspension
Bonds, Rail
Boxes, Electric—All Kinds
Brackets—All Kinds
Breakers, Circuit
Brushes—All Kinds
Brushes—Commutator
Bulbs—
  Carbon
  Mazda
Bushings—All Kinds
Buttons, Push All Kinds
Buzzers—All Kinds
Cabinets—
  Cutout
  Fire Alarm
  Panel Board
  Switch
Cable, Electrical—All Kinds
Cable Accessories
Canvas, Oiled
Cement—Commutator
Cells
Charts, Recording Instrument
Clamps—All Kinds
Cleats—All Kinds
Climbers, Linemen's
Clips—All Kinds
Closers, Circuit
Clusters, Light—All Kinds
Coils—
  Choke
  Induction
  Make and Break
Compound—Commutator
Compound, Insulating
Conductors, Steel Flexible
Conduits
Conduit Accessories
Connectors—All Kinds
Contacts
Controllers, Speed—Motor
Cord, Elec.—All Kinds
Couplings, Conduit
Cross Arms
Crossings, Trolley
Cutouts—All Kinds
Cutters—All Kinds
Detectors—
  Ground, Battery
  Time—Watchman's
Disconnectors, Line—Safety
Drills—All Kinds
Duck, Oiled
Ears, Trolley
Elbows
Extensions—All Kinds
Eyes, Anchor Rod
Fans, Desk
Fault Finders
Fiber—All Kinds
Fire Alarm Systems
Fire Pots
Flashlights
Floodlights
Frogs, Trolley
Furnaces—
  Gasoline
  Kerosene
Fuses—All Kinds
Fuse Plugs
Fuse Wires
Galvanometers
Gaskets—All Kinds
Gloves, Rubber
Gongs—All Kinds
Grips—
  Cable
  Linemen's
Guards, Lamp
Hammers, Electric
Hangers—
  Cable, Telephone
  Conduit
  Trolley
Harps, Trolley
Headlights
Horns—
  Fire Alarm
  Signal
Hydrometers, Battery
Indicators—
  Polarity, Battery
  Tank
Ink, Recording
Instruments—
  Portable
  Recording
  Switchboard
  Testing
Insulating Materials
Insulators—All Kinds
Irons, Electric Soldering
Jars, Battery
Joints—
  Insulating
  Splicing, Cable
  Wire Connector
Knobs—
  Glass
  Porcelain
Lacquer, Armature
Ladles, Pouring
Lamps—Electric, All Kinds
Lanterns, Battery
Line Material
Machines, Blasting
Magnetos
Magnet Wire
Meters—All Kinds
Mica—All Kinds
Milliammeters, Portable
Millivoltmeters—
  Portable
  Recording
Motor-Generators
Motors—All Kinds
Nail Heads, Leather
Nails, Insulated
Oil, Battery
Paint—
  Electrical Insulating
  Meter Board
Paper—
  Asbestos
  Emery
  Friction
  Oiled
Paraffine
Paste, Soldering
Pins—Insulator, All Kinds
Plates—All Kinds
Pliers—All Kinds
Plugs—All Kinds
Posts, Binding
Potheads—
  Metal
  Porcelain
Pouches, Linemen's
Racks—All Kinds
Receivers, Telephone
Reducers
Reflectors—All Kinds
Regulators, Speed—Motor
Relays—
  Circuit, Closing
  Starting, Motor
Rheostats—
  Blasting Machine
  Charging, Battery
  Field
  Load
Saddles, Cross Arm
Salts, Soldering
Scissors, Electrician's
Shades—
  Glass
  Metal
Shears—Electrician's
Sheets—
  Dial
  Meter Book
Shellac
Shields—
  Duct, Cable
  Expansion
Shunts, Meter
Signals—
  Fire Alarm
  Industrial
  Warning
Slate
Sleeves—
  Cable
  Lead
  Splicing—All Kinds
Sockets—All Kinds
Solder
Spurs, Linemen's
Staples—
  Copper
  Insulating
  Saddle
Starters—
  Motor
  Motor, Oil—Condit
Steps, Pole
Straps, Climber
Suspensions, Trolley
Switchboards
Switches—All Kinds
Syringes, Battery
Tackle, Linemen's
Tape, Insulating—All Kinds
Telephones
Terminals—All Kinds
Testers, Battery
Tool Bags, Linemen's
Transformers
Transmitters
Twine, Armature
Varnish, Insulating
Voltammeters
Voltmeters
Wattmeters
Wheels, Trolley
Wire—All Kinds

ELECTRODES—Arc-Welding

American Steel & Wire Co.....335

ELECTROLYTIC OUTFIT—Lead and Copper Assays

Braun-Knecht-Heimann Co.....770

ELEVATING AND CONVEYING MACHINERY

(See also Conveyors)
(See also Elevators)

Allis Chalmers Mfg. Co.....620
Bartlett, C. O. & Snow Co.....734
Gruendler Patent Crusher & Pulv. Co. 624
Hendrick Manufacturing Co.....645
Hendy, Joshua, Iron Works.....630
Jeffrey Mfg. Co., The...332, 656, 657
Link-Belt Co.....653, 654, 655
McLanahan-Stone Machine Co...492
Robins Conveying Belt Co.....658
Stearns-Roger Mfg. Co.....738
Webster Mfg. Co., The.....659
Weller Mfg. Co.....660, 661

ELEVATOR BELTS

(See Belts, Elevator)

ELEVATOR BUCKETS

(See Bucktes, Elevating and Conveying)

ELEVATORS—Belt

Jeffrey Mfg. Co., The.....656
Robins Conveying Belt Co.....658
Webster Mfg. Co.....659
Weller Mfg. Co.....660, 661

ELEVATORS—Bucket

Allis-Chalmers Mfg. Co.....491
Bartlett, C. O. & Snow Co.....734
Buchanan, C. G. Co., Inc....622, 623
Dodge Sales & Engineering Co...650
Gruendler Patent Crusher & Pulv. Co. 624
Jeffrey Mfg. Co., The.....332, 656
Link-Belt Co.....653, 654
Robins Conveying Belt Co.....658
Webster Mfg. Co., The.....659
Weller Mfg. Co.....660, 661
Worthington Pump and Machinery Corp. 493

ELEVATORS—Gravel (Hydraulic)

Hendy, Joshua, Iron Works 528

ELIMINATORS—Automatic

(See Traps, Steam)

EMERGENCY OUTFITS—First Aid

Mine Safety Appliances Co.....783
Safety First Supply Co.....786, 787

EMERY

(See Mine and Mill Supplies)

EMERY WHEELS

(See Mine and Mill Supplies)

ENCLOSURES—Wire

Wickwire Spencer Steel Corp....430

ENDLESS AND TAIL ROPE HAULAGE

(See also Engines, Haulage)

Mundy, J. S. Hoisting Engine Co..404

ENGINEERING INSTRUMENTS

(See Instruments, Engineering)

ENGINEERS—Civil

Hunt, Robt. W. & Co..... 83

ENGINEERS—Consulting, Contracting and Constructing

Denver Engineering Works Co...400
Dorr Company, The.....704, 705
Foundation Company, The..... 82
Groch Centrifugal Flotation Co...758
Hardinge Company.....628, 629
Hunt, Robt. W. & Co..... 83
Schaffer Engineering & Equipment Co. 672
Southwestern Engineering Co...759
Stearns-Roger Mfg. Co.....738
Wisconsin Bridge & Iron Co.....123

ENGINEERS—Mechanical

Groch Centrifugal Flotation Co...758
Hunt, Robt. W. & Co..... 83
Southwestern Engineering Co....759
Stearns-Roger Mfg. Co.....738

ENGINEERS—Metallurgical

Denver Engineering Works Co...400
Dwight & Lloyd Sintering Co., Inc.736
Groch Centrifugal Flotation Co...758
Hardinge Company.....628, 629
Hunt, Robt. W. & Co..... 83
Southwestern Engineering Co....759
Stearns-Roger Mfg. Co.....738

ENGINEERS—Mining

Hunt, Robt. W. & Co..... 83
Southwestern Engineering Co....759

ENGINE DRIVE—Turbo Gear

Poole Engineering & Machine Co. 224, 225

ENGINES—Blowing

Allis-Chalmers Mfg. Co.....168

ENGINES—Diesel

Allis-Chalmers Mfg. Co.....168
De La Vergne Machine Co.....177
McIntosh & Seymour Co.....179
Salt Lake Hardware Co.....277, 821
Worthington Pump and Machinery Corp. 176

ENGINES—Gas, Gasoline, Kerosene and Oil

Allis-Chalmers Mfg. Co.....168
Chicago Pneumatic Tool Co.....174
Colonial Supply Co.....831
De La Vergne Machine Co.....177
Dodge Sales & Engineering Co...178
Ingersoll-Rand Co.....170, 172
McIntosh & Seymour Corp.....179
Muncie Oil Engine Co.....180, 181
Pittsburgh Mining Machinery Co..810
Salt Lake Hardware Co.....277, 821
Worthington Pump and Machinery Corp. 176

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ENGINES—Gas, Gasoline, Kerosene and Oil (New and Used)
Kleinhans, H. Co.....502

ENGINES—Haulage
(See also Hoists, Electric)
Denver Engineering Works Co....400
Lake Shore Engine Works.....402
Mundy, J. S. Hoisting Engine Co..404
Salt Lake Hardware Co., The.277, 821
Vulcan Iron Works Co., The.....408
Wellman-Seaver-Morgan Co.....409

ENGINES—Hoisting
(See Hoists, Steam)

ENGINES—Marine
Ingersoll-Rand Co.....170
Morris Machine Works.....462

ENGINES—Semi-Diesel
Chicago Pneumatic Tool Co.....174

ENGINES—Steam
Allis-Chalmers Co.....168
Brownell Co., The.....153
Chicago Pneumatic Tool Co.....174
Ingersoll-Rand Co.....170
Mine and Smelter Supply Co.....632
Morris Machine Works.....462
Pittsburgh Mining Machinery Co..810
Sturtevant, B. F. Company.....161

ENGINE-GENERATOR SETS
(See Generator Sets, Engine Driven)

EXCAVATORS—Dragline
Hendy, Joshau, Iron Works.....529
Kleinhans, H. Co.....502
Marion Steam Shovel Co., The.496, 497

EXCITERS—Duplex
Terry Steam Turbine Co.....164

EXPANDERS—Boiler Tube
(See also Mine and Mill Supplies)
Ryerson, Jos. T. & Son.....122

EXPANDERS—Locomotive Tire
(See Heaters, Locomotive Tire)

EXPANSION BOLTS
(See Bolts, Expansion)

EXPANSION JOINTS
(See Joints, Expansion)

EXPLODERS—Delay Action Electric
(See Blasting Caps—Delay Action, Electric)

EXPLODERS—Fuse Lighted
(See Blasting Caps)

EXPLOSIVES—Black Powder
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....556
General Explosives Co.....559
Giant Powder Co., Con., The.....560
Grasselli Powder Co.....561
Illinois Powder Mfg. Co.....564
Salt Lake Hardware Co....277, 821

EXPLOSIVES—Blasting Gelatin
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....556, 557
General Explosives Co.....559
Giant Powder Co., Con., The.....560
Hercules Powder Co.....562
Illinois Powder Mfg. Co.....564

EXPLOSIVES—Dynamite (Ammonia)
Du Pont, E. I., De Nemours & Co, Inc.....556
General Explosives Co.....559
Grasselli Powder Co.....561
Hercules Powder Co.....562
Illinois Powder Co.....564

EXPLOSIVES—Dynamite (Gelatin)
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....556, 557
General Explosives Co.....559
Giant Powder Co., Con., The.....560
Grasselli Powder Co.....561
Hercules Powder Co.....562
Illinois Powder Co.....564

EXPLOSIVES—Dynamite, Granular (Judson or Railroad Powder)
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....557
Giant Powder Co., Con., The.....560
Hercules Powder Co.....562

EXPLOSIVES—Dynamite (Nitroglycerine)
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....557
General Explosives Co.....559
Giant Powder Co., Con., The.....560
Grasselli Powder Co.....561
Hercules Powder Co.....562
Illinois Powder Co.....564

EXPLOSIVES—Low Freezing
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....556, 557
Giant Powder Co., Con., The.....560
Hercules Powder Co.....562
Illinois Powder Mfg. Co.....564

EXPLOSIVES—Permissible
Atlas Powder Co.....555
Du Pont, E. I., De Nemours & Co., Inc.....556, 557
General Explosives Co.....559
Giant Powder Co., Con., The.....560
Illinois Powder Mfg. Co.....564

EXTINGUISHERS—Fire
(See Fire Extinguishers)

FABRICATED PIPE WORK
(See Pipes and Bends—Fabricated)

FANS—Building Ventilators
Buckeye Blower Co.....472, 473
Jeffrey Mfg. Co.....332, 475
Sturtevant, B. F. Co.....161

FANS—Forced Draft
Sturtevant, B. F. Company.....161

FANS—Mine (Centrifugal)
American Blower Co.....474
Buckeye Blower Co.....472, 473
Jeffrey Mfg. Co., The.....475
Pittsburgh Mining Machinery Co.810
Sturtevant, B. F. Company.....161
Salt Lake Hardware Co.....277, 821

FANS—Mine (Disc)
Buckeye Blower Co.....472, 473
Jeffrey Mfg. Co., The.....475
Pittsburgh Mining Machinery Co.810
Salt Lake Hardware Co.....277, 821

FANS—Mine (Metal Ducts)
American Blower Co.....474

FANS—Mine (Ventilation Tubing)
American Blower Co.....474
Buckeye Blower Co.....472, 473

FAULT FINDERS
(See Electrical Supplies)

FEEDERS—Apron
Jeffrey Mfg. Co., The.....656
Link-Belt Co.....654
Webster Mfg. Co.....659
Weller Mfg. Co.....660, 661

FEEDERS—Conveyor
Dodge Sales & Engineering Co...651
Groch Centrifugal Flotation Co...758
Jeffrey Mfg. Co., The.....656
Link-Belt Co.....654
Robins Conveyor Belt Co.....658
Webster Mfg. Co., The.....659
Weller Mfg. Co.....660, 661

FEEDERS—Disc
Grouch Centrifugal Flotation Co..758

FEEDERS—Grizzly
Chalmers & Williams, Inc.....621
Webster Mfg. Co., The.....659
Weller Mfg. Co.....660, 661

FEEDERS—Mine Car
Bartlett, C. O. & Snow Co.....734
Webster Mfg. Co., The.....659
Weller Mfg. Co.....660, 661

FEEDERS—Oil
Southwestern Engineeirng Co....759

FEEDERS—Ore
Allis-Chalmers Manufacturing Co.620
Chalmers & Williams, Co.....621
Dodge Sales & Engineering Co...651
Hendy, Joshua, Iron Works.....630
Jeffrey Mfg. Co., The.....656
Link-Belt Co.....654
Southwestern Engineering Co....759
Weller Mfg. Co.....660, 661

FEEDERS—Reciprocating
Card, C. S. Iron Works Co.....371
Jeffrey Mfg. Co., The.....656
Webster Mfg. Co., The.....659
Weller Mfg. Co.....660, 661

FEED WATER FILTERS
(See Filters, Feed Water)

FEED WATER HEATERS
(See Heaters, Feed Water)

FEED WATER TREATMENT
(See Water Softening and Purification)

FENCING—Wire
Wickwire Spencer Steel Corp.....430

FERRULES—Boiler
(See also Mine and Mill Supplies)
Colonial Supply Co.....830

FIBRE PRODUCTS—Insulating
(See Insulating Materials)

FIBRE ROPE SHIELD
Ironsides Company, The.....431

FIELD COILS
(See Coils, Armature and Field)

FILES
(See Mine and Mill Supplies)

FILLER—Wire Rope
Ironsides Co., The.....431

FILTER CLOTH
(See Cloth-Filter)

FILTER CLOTH—Metallic
(See Cloth—Filter)

FILTER PRESSES
Stearns-Roger Mfg. Co.....738
United Filters Corp.....709

FILTERS—Acidproof
United Filters Corp.....709

FILTERS—Boiler Feed Water
(See also Filtration Plants)
Permutit Company, The.....158
Scaife, Wm. B. & Sons Co.....159

FILTERS—Concentrate
Colorado Iron Works Co.....706
United Filters Corp.....709

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FILTERS—Continuous Vacuum
Colorado Iron Works Co.....706
United Filters Corp.....709

FILTERS—Continuous Vacuum (New and Used)
Morse Bros. Machinery & Supply Co. 820

FILTERS—Cyanide
Colorado Iron Works Co.....706
United Filters Corp.....709

FILTERS—Oil
(See also Mine and Mill Supplies)
Chalmers & Williams, Inc.....621
Permutit Company, The.....158

FILTERS—Pressure Leaf
United Filters Corp.....709

FILTERS—Rotary Pressure
Emil E. Lungwitz.....708

FILTERS—Water (For Dwellings, Swimming Pools and Industrial Uses)
Scaife, Wm. B. & Sons Co.....159

FILTERS—Water, Gravity
Scaife, Wm. B. & Sons Co.....159

FILTRATION EQUIPMENT
Permutit Company, The.....158
Scaife, Wm. B. & Sons Co.....159

FIRE ALARMS
(See also Mine and Mill Supplies)
Colonial Supply Co.....830
Federal Electric Co.....275, 280

FIRE BRICK CEMENT
(See Cement, Refractory)

FIRE ENGINES
(See also Fire Protection Apparatus)
Colonial Supply Co.....830
Howe Fire Apparatus Co.....793

FIRE EXTINGUISHERS
(See also Mine and Mill Supplies)
Colonial Supply Co.....832
Safety First Supply Co.....786, 787

FIRE PAILS
(See Fire Protection Apparatus)
(See also Mine and Mill Supplies)

FIRE PROTECTION APPARATUS AND SUPPLIES
Colonial Supply Co.....832
Howe Fire Apparatus Co.....793
Safety First Supply Co.....786, 787

FIRST AID CABINETS
(See Cabinets, First Aid)

FIRST AID CONTEST OUTFITS
Mine Safety Appliances Co.....783

FIRST AID PACKETS—Individual Dressing
(See also First Aid Supplies)
Hygienic Fibre Co.....788, 789
Safety First Supply Co.....786, 787

FIRST AID SUPPLIES
(See also Mine and Mill Supplies)

(Items embraced in this classification are listed below the names of firms)

Hygienic Fibre Co.....788, 789
Mine Safety Appliances Co.....783
Safety First Supply Co.....786, 787

Aromatic Spirits of Ammonia
Bandages—
Gauze
Roller
Triangular
Blankets—
Woolen
Rubber
Boric Acid
Camphenol
Castor Oil
Charts, Instruction
Chloramine
Compresses
Cotton, Absorbent
Cups, Drinking
Gauze—
Plain
Picric
Iodoform
Tissue
Glasses, Medicine
Inhalants, Ammonia
Internal Remedies
Lint
Litters
Oil of Salt
Packets, Individual Dressing
Packets, Pocket
Petrolatum, Borated
Plaster, Adhesive
Safety Pins
Disinfectants
Dressings—Eye, Surgical
Eye Cups
Eye Shields
Finger Cots
Forceps
Soap, Synol
Splints—Wire, Wood.
Stretchers
Tape, Adhesive
Tincture of Iodine
Tourniquets

FISH PLATES
(See Track Accessories)

FITTINGS—Brass (For Pipes and Valves)
Crane Company, The.....182, 183
Kelly & Jones Co., The 186, 187

FITTINGS—Cast Iron Pipe
American Car & Foundry Co.356, 357

FITTINGS—Lead Lined (For Pipes and Valves)
United Lead Co.....710, 711

FITTINGS—Pipe (Wrought and Steel) and Valves
(See also Pipe, Various Kinds)
(See also Mine and Mill Supplies)
American Spiral Pipe Co.....525
Byers, A. M. Company.....826
Crane Company.....182, 183
Kelly & Jones Co., The 186, 187

FITTINGS—Riveted Steel Pipe
Hendy, Joshau, Iron Works.....529

FITTINGS—Sanitary
Crane Company.....182, 183

FITTINGS—Wood Pipe
(See also Pipe—Wood)
Continental Pipe Mfg. Co.....526

FLANGES—Pipe
(See also Fittings, Metal Pipe)
Crane Company.....182, 183
Kelly & Jones Co., The.....186, 187

FLASHING—Zinc
American Zinc Products Co., The..120

FLASHLIGHTS
(See Electrical Supplies)

FLASKS—Carbide
(See also Mine and Mill Supplies)
Grier Brothers Co.....482
Justrite Mfg. Co.....483

FLATS
(See Structural Steel)

FLEXIBLE COUPLINGS
(See Couplings, Flexible)

FLIGHTS, TROUGHS AND PANS—Conveyor
(See also Elevating and Conveying Machinery)
Hendrick Manufacturing Co.....645
Webster Mfg. Co.....659
Weller Mfg. Co.....660, 661

FLOOD LIGHT PROJECTORS
General Electric Co.....242

FLOOD LIGHTS
(See also Electrical Supplies)
General Electric Co.....242
Westinghouse Elec. & Mfg. Co....248

FLOOR STANDS
Link-Belt Company.....655

FLOTATION CELL BOTTOMS—Cloth
Filter Fabrics Co.....707

FLOTATION CELLS—Redwood Lumber For
Pacific Lumber Co., The.....714

FLOTATION MACHINES
Allis-Chalmers Mfg. Co.....620
Colorado Iron Works Co.....639
Denver Engineering Works Co...400
Groch Centrifugal Flotation Co...758
Hendy, Joshua, Iron Works.....630
Southwestern Engineering Co...759
Stearns-Rogers Mfg. Co.....738

FLOTATION OILS
Cleveland-Cliff Iron Co., The...761
General Naval Stores Co.....762
Hercules Powder Co.....763
Southwestern Engineering Co....759

FLUES—Smoke
Hendrick Manufacturing Co.....645

FLUMES—Redwood Lumber For
Pacific Lumber Co., The.....527

FLUMES—Wood Stave
Continental Pipe Mfg. Co.....526

FLUMES—Steel
Hendy, Joshua, Iron Works.....529

FOOT ELBOWS—Lead Lined
United Lead Company.....710, 711

FOOTWEAR—Rubber
Goodrich, B. F. Rubber Co.....829

FOREHEARTHS—Smelting
Allis-Chalmers Mfg. Co.....740

FORGES—Oil (For Heating Drill Steel)
Denver Rock Drill Mfg. Co.....296
Hauck Manufacturing Co.....811
Ingersoll-Rand Co.....300

FORGES—Oil (For Rivet Heating)
Hauck Manufacturing Co.....811

FORGES—Shop
(See also Shop Machinery)
Bradley, C. C. & Son.....302
Hauck Mfg. Co.....811

FORGINGS
Allis-Chalmers Mfg. Co.....168
American Car & Foundry Co.356, 357
Duff Manufacturing Co.....827

FOUNDRY EQUIPMENT
Chicago Pneumatic Tool Co.....808
Colonial Supply Co.....830
Hauck Mfg. Co.....811

FOUNTAINS—Drinking
Safety First Supply Co.....786, 787

FRAMERS—Timber
Denver Engineering Works Co....400

FREQUENCY CHANGERS
Allis-Chalmers Mfg. Co.....168
Westinghouse Elec. & Mfg. Co...248

FRICTION TAPE
(See Tapes and Cloth Insulating)
(See also Electrical Supplies)

FROGS, TURNOUTS AND SWITCHES
American Frog & Switch Co.....370
Atlas Car & Mfg. Co., The.....371
Card, C. S. Iron Works Co.....372
Central Frog & Switch Co., The..372
Easton Car & Construction Co....359
Elliot Frog & Switch Co.....373
Foster, L. B. Co.....374
Frank, M. K.....375
Hendy, Joshua, Iron Works.....360
Indiana Foundry Co., Inc....350, 828
Pettibone Mulliken Co.....636

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FROGS—Trolley
(See also Line Material)
American Mine Door Co., The....352
Davidson, O. H. Equipment Co....354
General Electric Co.....331
Ohio Brass Co., The.....**353**
Westinghouse Elec. & Mfg. Co...252

FUEL ECONOMIZERS
(See Economizers, Fuel)

FURNACE CEMENT
(See Cement, Refractory)

FURNACES—Assay
(See also Assayers' and Chemists' Supplies and Equipment)
Braun-Knecht-Heimann Co.....**770**
Mine and Smelter Supply Co.....632
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  Solid Wire
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Braces, Cross Arm
Brackets—
  Pole
  Side
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Caps—
  Insulated
  Steel Bonding
Clamps—
  Bonding
  Feeder Wire Strain
  I Beam
  Suspension Insulator
  Trolley
Connectors, Wire
Cross-overs, Trolley
Ears, Trolley
Frogs, Trolley
Hangers—
  Feed-in
  Trolley
Insulators, All Kinds
Knobs, Porcelain—Insulating
Pins—
  Insulator
  Messenger Insulator
  Bond Expansion
Plugs, Wood Mine
  Hanger
Pull-Overs, Curve
Screws, Mine
  Hanger
Sleeves, Copper
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Slings—
  Feeder Wire
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  Feeder Wire
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  Disconnecting Knife
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Tape, Insulating
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LOCOMOTIVE HEADLIGHTS
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Ironton Engine Co.....338
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General Electric Co.....330, 331
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Jenkins Bros.....184, 185
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METAL—Asbestos Protected
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METAL—Monel
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Braun Corporation, The.....627
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Denver Engineering Works Co...400
Hardinge Company.....628, 629
Hendy, Joshua, Iron Works.....631
Mine and Smelter Supply Co.632, 633
Stearns-Roger Mfg. Co.....738
Worthington Pump and Machinery Corp. 626

MILLS—Ball and Tube (New and Used)
Morse Bros. Machinery & Supply Co. 820

MILLS—Centrifugal
Hendy, Joshua, Iron Works.....630

MILLS—Chilean
Chalmers & Williams, Inc.....621

MILLS—Combination Crushing and Screening
Allis-Chalmers Mfg. Co.....620

MILLS—Huntington
Chalmers & Williams, Inc.....621

MILLS—Pebble and Tube
Allis-Chalmers Mfg. Co.....620
Chalmers & Williams, Inc.....621
Colorado Iron Works Co.....638
Hardinge Company.....628,.629
Hendy, Joshua, Iron Works.....631
Worthington Pump and Machinery Corp. 626

MILLS—Roller
Gruendler Patent Crusher & Pulverizer Co.....624
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MILLS—Stamp
Allis-Chalmers Mfg. Co.....620
Chalmers & Williams, Inc.....621
Hendy, Joshua, Iron Works.....630
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(See Car Irons)

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MINE CAR TRUCKS
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Adzes
Anvils
Augers—All Kinds
Awls
Axes—Miners'
Anemometers
Anchors, Guy
Arbors
Asbestos Products and Materials
Axles
Babbitt Metal
Barrows—All Kinds
Bars—Iron and Steel
Bars—Jimmy and Pinch
Batteries—Dry and Wet
Bellows
Bells
Belting—All Kinds
Belt Dressing
Belt Lacing
Belt Tighteners
Benders—Rail
Bibbs—Compression
Bit Boxes
Bit Steel
Bits—Mining Machine
Black Powder
Blacksmiths' Supplies
Blades—Hack Saw
Blankets
Blasting Machines
Blasting Powder
Blasting Supplies
Blocks—Pulley
Blocks and Tackle
Blowers—Forge
Blow Torches
Boilermakers' Tools
Boilers
Boiler Trimmings
Boiler Tubes
Boiler Tube Expanders
Bolt Cutters and Clippers
Bolts and Nuts
Bolts—Expansion
Bolts—Eye
Bolts—Stay
Brackets—All Kinds
Brake Linings
Brass Goods
Brattice Cloth
Breast Drills
Brooms
Brushes
Buckets—Elevator
Buckets—Grease
Buckets—Water
Builder's Supplies
Burners—All Kinds
Bushings
Cabinets—First Aid
Cables
Cadgers
Calipers
Calking Tools
Candles
Cans—Oil and Waste
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Chain
Chalk and Crayon
Checks—Brass
Chemicals
Chisels—All Kinds
Chucks
Clamps—All Kinds
Cleaners—Flue
Clevises
Clips—All Kinds
Clocks
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Cocks
Coke Oven Supplies
Coke Scraper Heads
Collars—Horse and Mule
Collars—Shaft
Combs—Curry
Compound—Boiler
Concrete Mixers
Contractors' Supplies
Conveyors—Belt
Coppers—Soldering
Cord and Cordage
Cots
Cotters and Cotter Pins
Couplings—Hose
Couplings—Pipe
Couplings—Shaft
Coverings—Boiler and Pipe
Cranes—Shop
Cups—Grease and Oil
Cutters—Belt Lace
Cutters—Tube and Pipe
Cutting and Threading Machines
Detonators
Discs—Valve
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Drills—All Kinds
Drills—Miners' Post, Ratchet and Hand
Drills—Shop and Twist
Drill Presses
Dryers—Sand
Duck
Dynamite
Ejectors
Electrical Supplies
Emery
Emery Cloth and Paper
Emery Wheels
Engineer's Supplies
Engines—Steam and Oil
Expanders—Tube
Explosives
Extinguishers—Fire
Fans—Desk and Mine
Farriers' Tools
Fasteners—Belt
Fencings—Wire
Ferrules
Figures and Letters—Steel
Files
Filters—Oil
Fire Alarms
Fire Extinguishers
Fire Pails
First Aid Supplies
Fittings—Boiler and Engine
Fittings—Pipe
Flanges—All Kinds
Flasks—Carbide
Flasks—Powder
Flue Cleaners and Scrapers
Forges
Forgings
Forks—Coke
Foundry Supplies
Furnaces
Fuses
Fusible Plugs
Galvanized Ware
Gaskets and Gasket Tubing
Gas Supplies
Gauges—All Kinds
Gauge Cocks
Gauge Glasses
Gimlets
Glass
Globes—Lamp and Lantern
Gloves—Rubber and Canvas
Glue
Gongs
Governors—Engine
Graphite—Boiler
Graphite—Lubricating
Greases—All Kinds
Grease Cups
Grease Guns
Grinders
Grindstones
Guards—Safety
Hack Saws and Blades
Hammers—All Kinds
Handles—Tool
Hangers—Pipe and Shaft
Hardware
Harness Supplies
Hatchets
Headlights
Heaters
Hinges
Hitchings—Mine Car
Hoists—Chain (Shop)
Hooks
Hose—All Kinds
Hose Couplings
Hose Racks
Hydrants
Indicators—Engine
Injectors
Inspirators
Insulating Material
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Jacks—All Kinds
Joints—Expansion
Joints—Pipe
Kettles
Keys
Knives
Ladders
Ladles
Lamps—Carbide and Oil
Lamps—Carbon and Mazda
Lanterns
Latches
Lathes
Lathe Tools
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Leather—Hydraulic
Leather—Lace
Leather Packings
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Locks
Lubricants—All Kinds
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Lumber
Machinery—Woodworking
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Mandrels
Masons' Tools
Matting—Rubber
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Mauls—Spike
Mechanical Rubber Goods
Metal—Bearing
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Meters
Mica
Miners' Tools and Supplies
Motors
Nails
Needles—Tamping
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Nozzles
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Oakum
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Oilers—All Kinds
Packing—All Kinds
Pails and Buckets
Paints—All Kinds
Paper—Blasting
Paper—Building and Roofing
Picks—All Kinds
Pillow Blocks
Pipe—Cast Iron, Steel, Iron, Brass and Lead
Pipe—Fibre
Pipe Fittings
Pipe Threading Tools
Plates—Steel and Iron
Pliers
Plumbing Fixtures and Supplies
Portable Cranes
Pots, Glue
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Power Transmission Machinery and Supplies
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Pumps—Power
Pumps—Steam Jet
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Ratchets
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Resin
Revolution Counters
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Rivets
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Rope—All Kinds
Rope Accessories—Wire
Rosin
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Scales—Platform
Scoops
Scraper Heads—Coke
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Separators—Oil, Steam and Water
Shackles
Shafting and Appurtenances
Sheaves
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Sheets—Steel
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Shop Machinery
Shovels
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Sisal
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Solder
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Stable Fittings
Steam Fitters' Tools
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Steam Specialties
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Thermometers
Tents
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Tools—High Speed
Tools—Shop
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Torches
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Traps—Steam
Trolleys
Trucks—Hand
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Tubing—Brass, Copper and Steel
Turnbuckles
Twine
Unions—Pipe
Valves and Cocks
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Products Described or Illustrated in the Catalog Sections Are Shown in **Black Face Type**; Products Merely Mentioned Are Shown in Light Face Type.

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SECTION I

Engineering, Prospecting and Exploration

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Buff & Buff Mfg. Co.
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Sullivan Machinery Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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GEOLOGICAL DEFINITIONS*

ALTERATION—A change in which part of the original material is removed; the term may, but need not necessarily, imply the addition of new material.

ARENACEOUS—Term applied to rocks made up of sandy material.

ARGILLACEOUS—Clayey, as for instance argillaceous limestone.

BANDED STRUCTURE—A term applied to vein formation in distinct layers or bands. This may be due to successive periods of deposition, to replacement of some earlier formation, or to movement and sheeting subsequent to deposition.

BATHOLITH—A large rock mass which has solidified at great depth; the rock is coarse in texture due to slow cooling.

BEDDED DEPOSIT—One which forms a layer or bed of a bedded formation.

BEDDED FORMATION—One which shows successive beds, layers or strata, due to the manner in which it was formed.

BEDDING PLANE—The surface between two successive beds or strata of a bedded formation. It is marked by some slight change in the nature of the material, such as a clayey seam between limestone beds.

BRECCIA—A rock formation composed of angular fragments.

CHIMNEY—A term applied to an ore body of much greater vertical extent than its dimensions in horizontal section, which may be roughly circular or elliptical.

CONFORMABLE—A term applied to a later formation the bedding planes of which are parallel with those of an earlier formation. (See Unconformity.)

CONGLOMERATE—A rock composed of waterworn material of various sizes from sand to boulders.

CONTACT—The line along which an igneous and a sedimentary formation meet—as a "granite-limestone" contact. Sometimes more broadly used, especially in underground descriptions to designate any boundary.

CONTACT DEPOSIT—One formed on or near a contact and presumably owing its origin to activities accompanying or following an igneous intrusion.

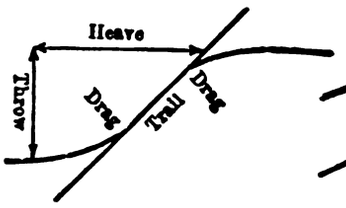
CONTACT METAMORPHISM—A general term applied to the changes which take place along a contact—such as recrystallization of limestone, or silicification (producing "flints or hornstones"), and the formation of the typical silicate minerals.

COUNTRY ROCK—Any rock formation which forms the walls of, or encloses an ore deposit.

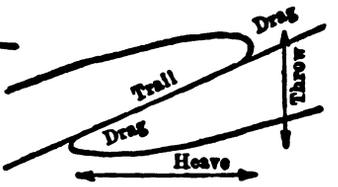
DECOMPOSITION—The breaking up of a rock or mineral into its component parts.

DETRITUS—Detrital material, loose material resulting from the weathering and wearing down of a rock formation.

DRAG—Faults often cut relatively soft beds, as shales or shaly sandstones. Friction of the walls upon each other causes a downward bend in the beds of stationary or lifted side and an upward bend in those of the moving or dropped side. These bends are called DRAG, and show the direction of movement.



†Fig. 1. Normal Fault, showing Drag, Trail, Heave and Throw.



†Fig. 2. Reverse Fault, showing Drag, Trail, Heave and Throw.

DRIFT—Unsorted material transported by a glacier.

ENRICHMENT—The action of natural agencies which increases the metallic content of an ore. Secondary sulphide enrichment refers to the formation of new sulphide minerals which contain a larger percentage of the metals.

EROSION—The wearing away of rock masses under the influence of water and wind.

FAULT—A break in the rock formations accompanied by movement of either or both sides.

DIP FAULT—A fault the strike of which is parallel to the direction of the dip of faulted strata.

NORMAL FAULT—A fault of which the "hanging," or upper wall, has moved down with respect to the lower wall or "foot."

OBLIQUE FAULT—A fault the strike of which makes an angle with the directions of both strike and dip of the faulted formation.

REVERSE FAULT—A fault of which the "hanging" (upper) wall has moved upward with respect to the "foot" (lower) wall.

DIP—The angle which an inclined bed or vein makes with the horizontal, measured at right angles to the strike.

DISSEMINATED DEPOSIT—One in which small patches or specks of minerals are scattered irregularly through the rock formation of a considerable area.

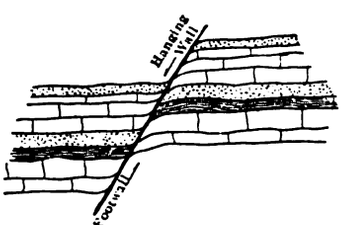


Fig. 3. Normal Fault.

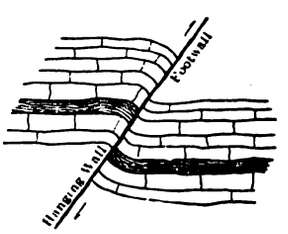


Fig. 4. Reverse Fault.

*"Farrell's Practical Field Geology," and "Spurr's Geology Applied to Mining." (McGraw-Hill Book Co.)

†"Peele's Mining Engineer's Handbook." (Wiley & Sons).

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FISSURE VEIN—A common form of ore deposit with well defined walls and roughly tabular shape, the length and vertical extent being great compared to the width. The idea commonly current that a "true fissure vein" may extend "right down to the center of the earth" has been discredited in the light of later investigations. It is now recognized that veins and other ore deposits have a fairly definite vertical extent, though it is rarely that mining operations are carried to such depth as to expose the lowest portions.

FLOW STRUCTURE—The traces of movement or currents in rock masses which solidify from a molten condition on the surface of the earth. The lavas before solidification are viscous or sticky liquids.

FOLD—A form of geologic structure resulting from the crumpling or flexing of rock masses.

ANTICLINAL FOLD (or ANTICLINE)—A fold or arch of the rock strata or beds the sides (limbs) of which diverge downward.

CLOSED FOLD—A fold in which the limbs (sides of the arch) have been compressed till they are parallel.

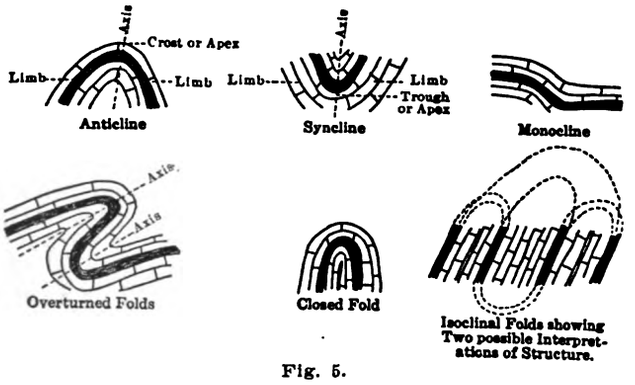

Fig. 5.

ISOCLINAL FOLD—A closed fold in which the folded beds have the same dip. Often with a series of isoclinal folds the crests of the anticlines have been eroded and the troughs of the synclines cannot be seen, so that the true structure is hard to determine.

MONOCLINE—A fold in which the strata have been subjected to a simple flexure, producing dips in one direction and in one direction only.

FOOT WALL (or FOOT)—The lower wall of a fault, vein or other form of ore deposit.

GANGUE—A term applied to the earthly or non-metallic minerals occurring in ore deposits; such as quartz, barite, fluorite, calcite, etc.

GASH VEIN—A vein which does not extend beyond a certain bed or formation.

GNEISSOID—A term applied to rocks of coarse texture which have been crushed or sheared, developing bands or laminations.

GOUGE—Soft clayey material found in faults or veins, resulting from alteration of the country rock and crushing due to subsequent movement.

GRANITOID TEXTURE—The texture of granites, gabbros, etc., resulting from the slow cooling of the rock mass and the formation of minerals without crystal boundaries.

GROUND WATER LEVEL—The level at which permanent water is encountered at depth. The water level is not a plane surface, but varies with the character of the ground surface, rising somewhat under hills and often exposed in the valleys except in dry regions.

HANGING WALL (or HANGING)—The upper wall of a fault, vein or other ore body.

HEAVE—In describing a fault the heave is the "offset" or shift of an index plane, as shown in a horizontal section or plan.

HORSE—A mass of barren material, usually country rock, occurring in a vein.

HOLOCRYSTALLINE—A term defining rock texture in which all of the minerals are crystallized.

IGNEOUS—A term applied to agencies involved in or resulting from the formation of rocks from molten masses; also used to designate in a general way the rocks which have resulted from the solidification of molten masses either upon the surface, or in the depths of the earth. Thus we speak of the igneous origin of certain ore deposits; periods of igneous activity, etc.

IMPREGNATION—The process which results in the general distribution of small mineral particles throughout a rock mass; for instance, "Impregnation of the wall rock with pyrite and other sulphides in small quantities is very common."

INDEX PLANE—A surface of any bed, dike, or vein which may be regarded as a plane and used as a basis for measurements of fault movements.

INTRUSION—An igneous rock mass which has been forced into some formation of earlier age.

JOINT—A fracture in a rock mass due usually to cooling from a molten condition, or cooling and cracking from atmospheric changes of temperature.

KAOLINIZATION—The decomposition of certain rock forming minerals to kaolin or clay.

LACCOLITH—A rock mass of moderate size roughly circular in outline, formed beneath a dome of overlying rocks.

LEACHING—The solution and removal of some of the original constituents of a formation.

LODE—A form of ore deposit in which several veins lie close together, so that in places the ground between them is ore-bearing and the entire width may be mined.

MAGMA—A magma is a solution of rock-forming elements. It is an elementary mass in which there has been no crystallization or separation of the rock-forming minerals.

METAMORPHISM—A change in the form or character of the constituents of a rock, which may frequently, but need not necessarily, imply a change of chemical composition due to the addition of new material. Metamorphism may result in the development of gneissoid or schistose structure; or the formation of crystals as in the case of crystallized limestone. In some cases entirely new minerals are formed.

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METAMORPHIC ROCKS—Those which have been subjected to changes in texture or chemical composition or both.

METASOMATISM—Means literally the making over of a formation. It is the change in composition through chemical interchange, by which a mineral or an aggregate of minerals is partially or completely altered. Replacement is a synonym.

MINERALIZERS—The vapors held in an igneous magma which are active in the development of minerals. Such gases are steam, hydrofluoric acid, boracic acid, etc.

ORE—An ore is any mineral or aggregate of minerals containing one or more of the useful metals and occurring in a natural state in such quantities as to be the object of mining operations.

PAY ORE—Is ore which may be mined and treated at a profit under existing conditions.

NON-PAYABLE ORE—Is ore which cannot be extracted profitably under existing conditions. For instance, the disseminated copper deposits, containing 1.5 per cent. to 2.5 per cent. copper, were not recognized as pay ores until a process of concentration had been developed permitting the profitable extraction of the copper. Such ores were, however, the object of unsuccessful mining operations in earlier times. A gold ore assaying $10.00 per ton might be classed as pay ore in one mine, while in another mine it could not be extracted at a profit owing to less favorable natural conditions, or lack of transportation facilities. Here it would be classed as non-payable. Sometimes the practice prevails of classing as ore all the minerals that may be mined at a profit and calling all material below that grade "rock."

ORE SHOOT—The richer portion of a vein or other ore deposit.

OUTCROP—The portion of a formation that is exposed at the surface of the ground.

OXIDATION—The formation of oxides or the conversion of minerals into oxidized forms by the addition of oxygen, usually derived from the air.

OXIDIZED ZONE—That portion of an ore deposit which has been subjected to the action of surface waters carrying oxygen, carbon dioxide, etc.

PAY SHOOT—A portion of a deposit composed of payable ore.

PLUTONIC ROCKS—Those which have cooled in the depths of the earth.

PNEUMATOLYSIS—The setting free of vapors from igneous masses and the effects produced by such vapors. Pneumatolytic minerals are those produced through the agency of vapors or gases.

PRIMARY MINERALS—Primary sulphides—those which retain their original form and composition.

PORPHYRITIC—A rock texture in which separate crystals are prominent, and are surrounded by a mass of finer material.

PSEUDOMORPH—A mineral retaining the form of some earlier mineral which it has replaced.

REPLACEMENT—The process by which one mineral or chemical substance takes the place of some earlier different substance, often preserving its structure or crystalline form.

ROCK—Is a mineral or aggregate of minerals, forming an essential part of the earth; but many important mineral bodies, such as ores of metals, are not to be considered as rocks. Of about 1,000 species of minerals, only 20 or 30 per cent. are important as rock constituents.

The three great classes or rocks are: IGNEOUS, solidified from fusion; SEDIMENTARY, deposited in water or air; METAMORPHIC, recrystallized or otherwise altered igneous and sedimentary rocks, such that their original character has been obscured. Igneous rocks are believed to have been predecessors and source of all others.

Most abundant elements of rock-forming minerals are: silicon, oxygen, aluminum, iron, magnesium, calcium, sodium, potassium, and hydrogen; secondarily, carbon, chlorine, phosphorus, titanium, manganese, and sulphur. All other elements, even the familiar copper, lead and zinc, and the precious metals, or an abundant atmospheric gas, as nitrogen, are comparatively unimportant.

Chemical Composition of Rock-Forming Minerals

Rock-forming minerals comprise silicates, oxides, carbonates, sulphates, chlorides, phosphates, sulphides and native elements.

SILICATES are the most important, whence silicic acid, in various forms, is the foremost acid in Nature. They may be divided into two general classes: Anhydrous and Hydrous silicates. The former are combinations of silicic acids with various common bases and are usually primary; the latter are usually formed by weathering or alteration of the first, containing hydrogen and oxygen in such proportions as to be driven off as water.

OXIDES are next important, of which quartz (SiO_2) and its hydrous forms stand first, being abundant in all the great classes of rocks. Next in importance are the oxides of iron, and the commonly related oxides of titanium and chromium.

Carbonates are important existing as carbonates of calcium, magnesium and iron or other combinations.

SCARP—A steep slope, usually formed by the weathering of the up-thrown side of a vertical or steeply dipping fault.

SCHISTOSE—A term applied to rocks of fine texture which have been crushed and sheared, so that the original minerals or particles are flattened and elongated, developing thin parallel leaves or laminations.

SECONDARY MINERALS—Those which result from the alteration of earlier minerals. Secondary sulphides are those which are made richer in their metallic content by the addition of material resulting from the oxidation of other portions of a deposit.

SEGREGATION—The local gathering or concentration of particles of the same substance.

SHEAR ZONE—A line along which a rock formation has been crushed and broken or sheeted, but not clearly broken and displaced as by a fault.

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SHEETING—The development of small closely spaced parallel fractures.

SHEET (or SILL)—A relatively thin, flat, tabular intrusive mass.

STRATIFICATION—The layering or bedding of a rock formation due to deposition in successive stages.

STRIAE—Scratches or grooves produced on rock surfaces by faulting or glacial action. Also parallel bands seen on the cleavage faces of the plagioclase feldspars, caused by twinning in the growth of the crystal.

STRIKE—The direction of the intersection of a bedding plane, or the plane of a dike, vein, or fault with a horizontal plane.

STRINGER ZONE—A system of small mineralized fractures or stringers having the same general strike.

STRUCTURE—Those features of geological formations which have to do with their composition or building up on a large scale. Thus folding and stratification are structural features.

TEXTURE—Is a term applied to the characteristics of a rock when studied in a detailed way. It refers to the composition of specimens rather than of large masses.

UNCONFORMITY—A structural feature produced by the deposition of a later formation upon a tilted or partially eroded earlier formation.

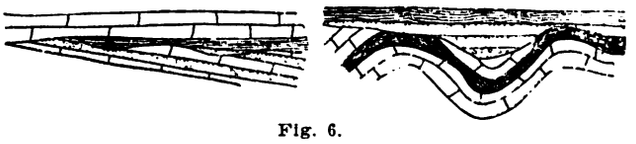

Fig. 6.

VEIN—A mineralized fissure; a deposit of slight width compared to its length and vertical extent. It may or may not have well-defined walls.

VEIN SYSTEM—A term applied to the veins of a given area, district, or age, regarded as a whole.

WASH—Loose material which has been transported some distance from the source.

WEATHERING—The change in a rock formation produced by atmospheric agencies.

ZONE—A belt or strip of any formation which is distinguished from adjoining portions by certain general characteristics.

ELIMINATING WASTE IN ESTIMATING*

A report on quantity surveying and payments for estimating, with recommendations to owners and investors, architects, engineers and contractors, has been approved and adopted by the American Institute of Architects, American Engineering Council of the Federated American Engineering Societies, and the Associated General Contractors of America.

The purpose of this report is to acquaint prospective owners and others financially interested in building and other construction projects with the wasteful duplication and consequent expense involved in the preparation of estimates of quantities under the systems now generally in vogue. The recommended procedure of quantity surveying is intended to eliminate the present wasteful and uneconomical methods by concentrating the function of determining and compiling the quantities and list of work involved in one agency for each project, this quantity survey to be submitted to all bidders with the plans and specifications.

Specific recommendations are:

1. **Quantity Surveying.**—Architects, engineers and contractors should jointly use their efforts to have established facilities for making quantity surveys.

2. **Payment for Quantity Surveying.**—The owner should pay for the quantity survey from ¼ per cent. to 1 per cent. of the cost of the project for commercial and public work and not more than twice as much for residence work, whether the project is constructed or not.

3. **Cost of Project.**—The cost of the project may be defined as the accepted bid, or in cases where no bid is accepted, the bid of the lowest responsible bidder as determined by the architect or engineer. However, in cases where alternate bids are required, the additional payments for the quantity survey shall be based upon the additional quantities surveyed, as approved by the architect or engineer.

4. **Altered Plans.**—Altered plans which involve a change in quantities after the quantity survey has been made justify an addition to the original fee for quantity surveying.

5. **Basis of Contract.**—Owners should have the option of: (a) Making the quantity survey a part of the contract; (b) permitting the successful bidder, at his own expense, an opportunity to verify the accuracy and completeness of the quantity survey before the contract is signed. If he proves errors to exist in the quantity survey, the bidder shall be permitted to adjust his bid accordingly.

6. **Unit Quantities and Standards.**—The schedule of unit quantities should conform to local customs or methods of measurement and should be so stated on the quantity survey. The eventual adoption of national standards is recommended.

7. **Guarantee.**—The guaranteeing of quantities by a quantity surveyor is not recommended, for it might influence the surveyor to protect himself by increasing the quantities. The extra cost of a guarantee would not be warranted.

8. **Existing Methods.**—The cost to owners of preparing bids by existing methods, which make necessary wasteful duplication in estimating quantities by several bidders, is known to be much greater than the cost of preparing bids based on a quantity survey furnished by the owner, and therefore such existing methods are condemned and should be discontinued.

*From Mining and Metallurgy.

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GRAPHICAL DETERMINATION OF DIP AND STRIKE*

The usual method of taking observations upon the dip and strike of a vein, and calculating or plotting of probable underground sections, is often about as satisfactory as a topographical map would be with the elevations plotted, but without contour lines. Any scheme, which will present a picture of the form and elevation of a vein, that can be comprehended almost at a glance, has many advantages over a collection of elevations. Nothing seems to accomplish this purpose better than contour lines.

Finding the dip and strike of a vein graphically, with the elevations of the projected points shown by contour lines, is not only a clear presentation of the probable location of the vein, but is also a more accurate determination of its dip than could otherwise be obtained. The projected points in Fig. 2 may seem unreasonably far, but the dependence that can be put upon the direction and continuation of a vein beyond accessible points, rests largely upon the geological character of the country. Although the projection of a vein is not to be considered too seriously in any event, yet its apparent position from known data is evidence upon which to plan development work.

A plane passing through an uneven surface will cut the latter in an uneven line; the course of this line being dependent upon the contour of the surface and the angle of the cutting plane. Therefore, the angle of the plane can be determined by the course of this line of intersection, by reason of the fact that three points not in a straight line will determine a plane. Similarly, the course of the outcrop of a vein along an uneven surface determines the dip and strike of the vein. The accuracy is greatly increased if there are shafts and workings to permit underground observations. When there are no workings on the vein, points should be selected at the greatest extremes, as in the bottoms of gulches and on the crests of ridges.

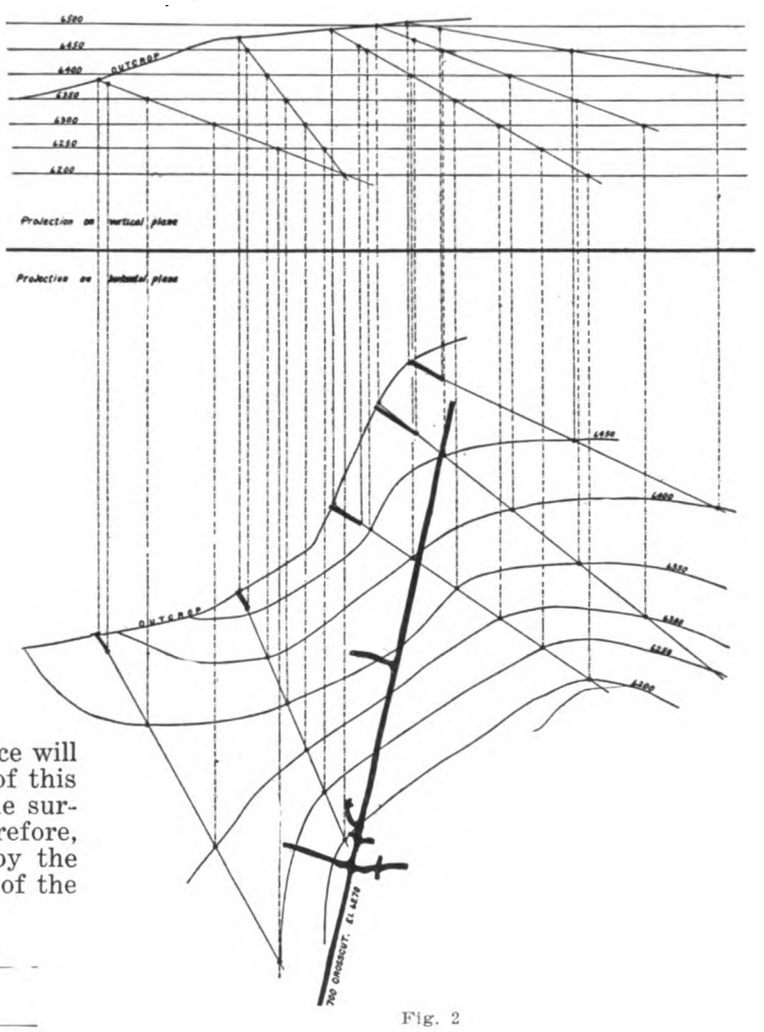

Fig. 2

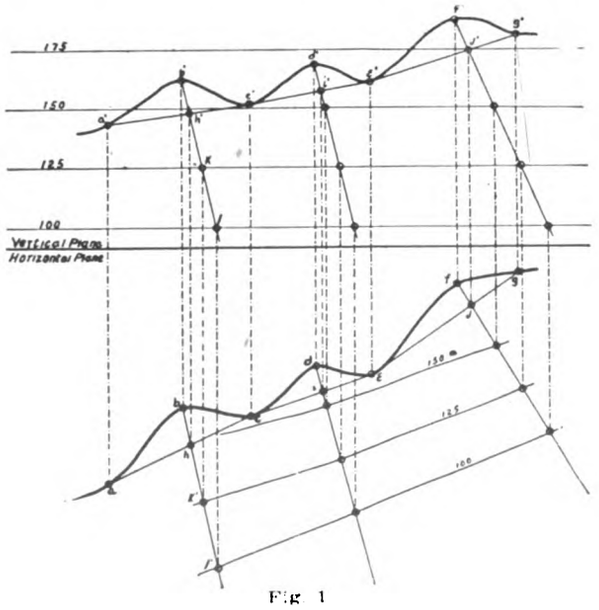

Fig. 1

Fig. 1 is a hypothetical case showing an outcrop over uneven ground. The points a, b, c, etc., are located from field notes and projected to their proper elevations a′, b′, c′, etc., in a vertical plane. A straight line is now drawn connecting a and c. Another straight line, bh, is drawn in a direction approximately at right angles to the strike and intersecting the line ac. Since a, b, c, and the line ac lie in the same plane, therefore a line drawn from b intersecting any point on the line ac, also

*R. C. Cameron in Mining and Sci. Press.

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lies in the same plane. Hence bh and bh extended lie in the same plane, abc. The points a′, c′, are connected with a straight line, and the point of intersection h projected to h′. Then b′ h′ is drawn and extended. The lines 100, 125, 150, 175 in the front elevation represent horizontal planes. The intersections of the line b′ h′ with these planes are k and l, which are now projected to k′ and l′, and show the positions on the map at which the vein has elevations of 125 and 100 ft., respectively, provided the vein continues in the same plane as at abc. The same process is repeated at cde and efg, and the elevations determined along the lines di and fj extended. Points of equal elevation are connected with contour lines, and the dip and strike are thus shown along the entire surveyed course of the vein and at any depth that seems consistent with the points of observation and the supposed regularity of the dip.

Fig. 2 was made two years ago of a vein with considerable variation of dip and strike. Subsequent development work, however, has shown that it nearly coincides with these contours, which were determined and drawn by this method. The advantages of knowing the shortest distance to a vein and directions in which the drifts will run, after the vein is reached, and of having these data cover the entire section of interest can be seen very clearly in this figure. In this case observations were taken in inclined shafts, so that it was necessary to use only two points to produce a line downward through the vein. A point at the collar and one at the bottom of each incline were determined, which correspond to b and h, respectively, in the horizontal plane, and b′ and h′, respectively, in the vertical plane of Fig. 1.

Fig. 3 was mapped from a Brunton compass survey of a prospect. Construction lines by which the contours were determined have been omitted in this copy; only the results are shown. The outcrop had not been found east of the eastern extremity shown on the map. The decided curves of the contour lines on the eastern side suggested the possibility of a fault, which upon later investigation was found to exist. A considerable displacement had occurred, in which that portion of the section shown on the map had moved to the north, just as indicated by the contour lines. This simple case serves to illustrate the advantages

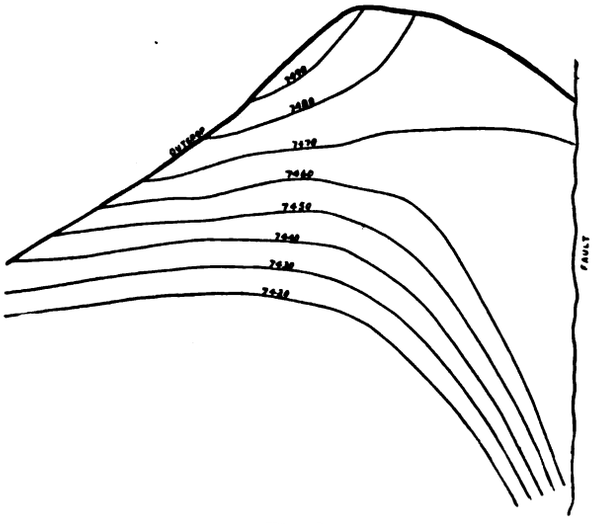


Fig. 3

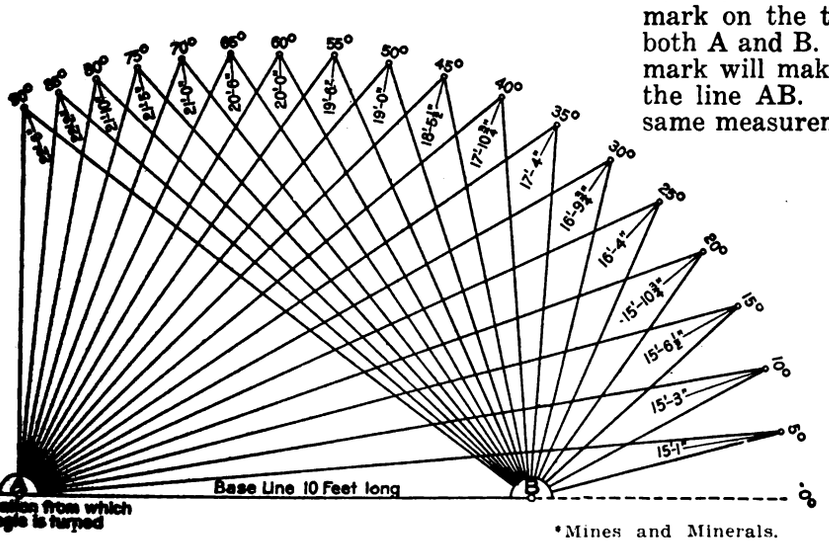
which may be derived, by this method, in working out geology, as well as in planning development work.

TO LAY OFF AN ANGLE WITH TAPE*

The following chart will be useful for laying off angles underground, when there is no compass at hand or on account of local attraction a compass cannot be depended upon.

The chart shows how to lay off an angle from a point A on a line AB to the left.

Explanation—Fasten the O end of the tape at A, then stretch the tape to B, a distance of 10 feet and fasten the 10-foot mark at B, next find the 30-foot mark on the tape, carry and fasten it at A. This will leave 20 feet of slack tape between A and B. For an angle of 50 degrees find the 19-foot mark on the tape, and draw the tape tight from both A and B. The tape line from A to the 19-foot mark will make an angle of 50 degrees at A from the line AB. For an angle to the right, use the same measurement on the right of the base line.



AREA OF CIRCLE

$$(\text{Radius})^2 \times 3.1416$$

or

$$(\text{Diameter})^2 \times .7854$$

Cubic Contents of Cone

$$\frac{\text{Area of Base}}{3} \times \text{Depth}$$

*Mines and Minerals.

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Use of Descriptive Geometry in Mining*

I. TO FIND THE STRIKE.

As the simplest and most fundamental problem, let it be required to find the strike of a vein when the location and elevation of three points on the outcrop are known. It will be assumed for the present that the vein is a plane.

In Fig. 4 let A, B, and C be three points on an outcrop, their elevations, as found by observation or shown by contour levels, being as noted. Connect A and B, B and C, giving the plan-view of two lines lying in the plane of the vein. If a side-view be drawn, as shown beneath the plan. A, B, and C will appear as Av, Bv and Cv, (the v-subscript indicating a vertical projection), and a horizontal plane through A will appear as a horizontal line through Av. Dv, where the line $BvCv$ cuts the plane, is the side-view of a point in the vein on the same level as A. Projecting up to the line BC, this point appears in the plan-view at D. Two points in the plan-view, such as A and D, on the same level and both in the vein, determine the strike. A saving in line-work might be made by drawing the line representing the side-view of the horizontal plane through A itself instead of through its projection, Av, using the same construction otherwise. It is clearer, for the present purpose, to show the side-views separately instead of partly superimposed.

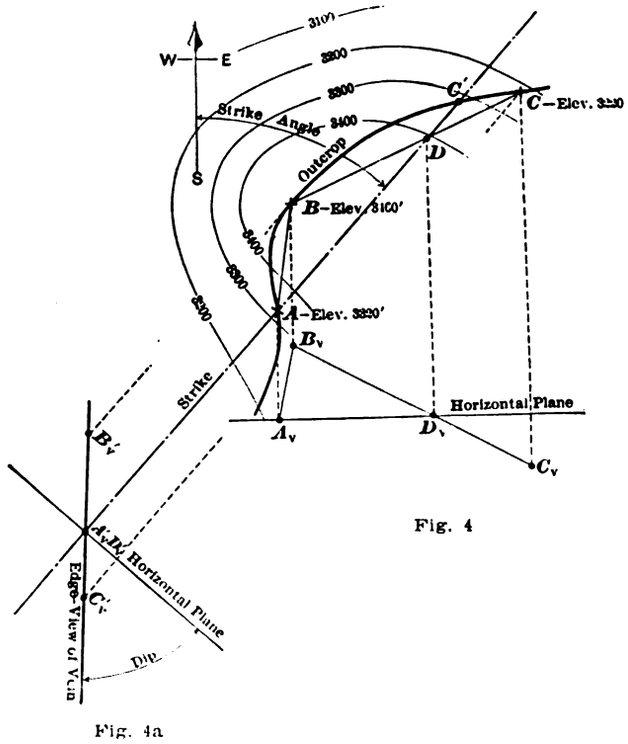

Fig. 4

Fig. 4a

If a point on the outcrop at the same level as A can be located, as C′, the line from A to C′ will at once give the strike. A third point, B, will, however, be necessary to determine the dip, as a plane cannot be located with less than three points.

*Roe in Trans. A. I. M. E.

II. TO FIND THE DIP.

Having found the strike, take a side-view of the vein looking up the strike-line. The points A, B, C, and D and the plan-view will appear as shown. The line through $B'v$, $C'v$, etc., Fig. 4a, is the edge-view or end projection of the vein, and the dip is, of course, the angle included between this and the horizontal plane.

The dip might also be found by passing a vertical projecting-plane through B perpendicular to the line of strike, and then revolving the line of intersection of this plane and the vein into the plane of the paper. This is the characteristic method of descriptive geometry, but when the engineer wants to detail some part which stands at odd angle with the rest of his drawing, as, for instance, a hand-hole plate or a sky-light, he does not adhere rigidly to his right-angled projections, but draws an oblique view looking squarely at the detail, showing it directly and giving the dimensions without any troublesome revolvings. By taking a side-view up the line of strike many problems which otherwise might be troublesome are reduced to the very simplest terms. As examples of this take the following:

III. DEPTH OF SHAFT.

Given the points on an outcrop as before, how deep must a shaft be sunk at some point, S, to strike the vein?

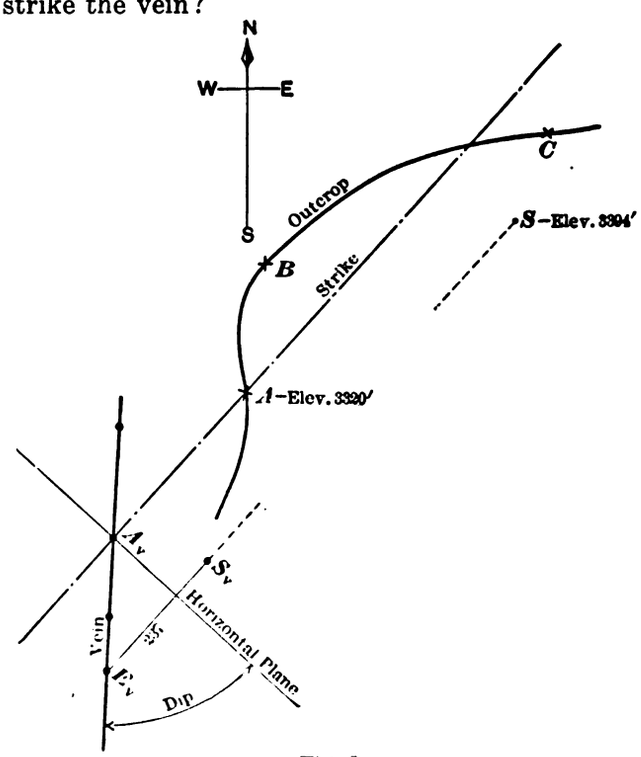

Fig. 5

The strike and dip having been found, we have the side-elevation of the vein, as shown in Fig 5. The point, S, from which the shaft is to be sunk appears as Sv at its proper elevation, and the depth of the shaft is obtained at once by scaling $SvEv$.

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IV. LENGTH OF A TUNNEL.

Suppose it is proposed to drive a tunnel with, say, a 5 per cent. upgrade from some point, T, Fig. 6, to the vein. Where will it hit the vein, how long will it be, and what will be its bearings?

Find the strike and side-view. Project the point T to T*v*. Draw a line, T*v*M, parallel to the horizontal plane, and T*v*N, making an angle with T*v*M corresponding to the grade. T*v*F*v* is, to scale, the length required. In the plan-view it is obvious that the tunnel will appear at right angles to the strike, which gives at once the bearing-angle. Project F*v* up to meet this line, as at F, and we have the plan-view of the point of intersection of the tunnel and the vein. The elevation of F may be obtained by trigonometry, or more simply still by scaling the difference in level between F*v* and the horizontal plane through A*v*.

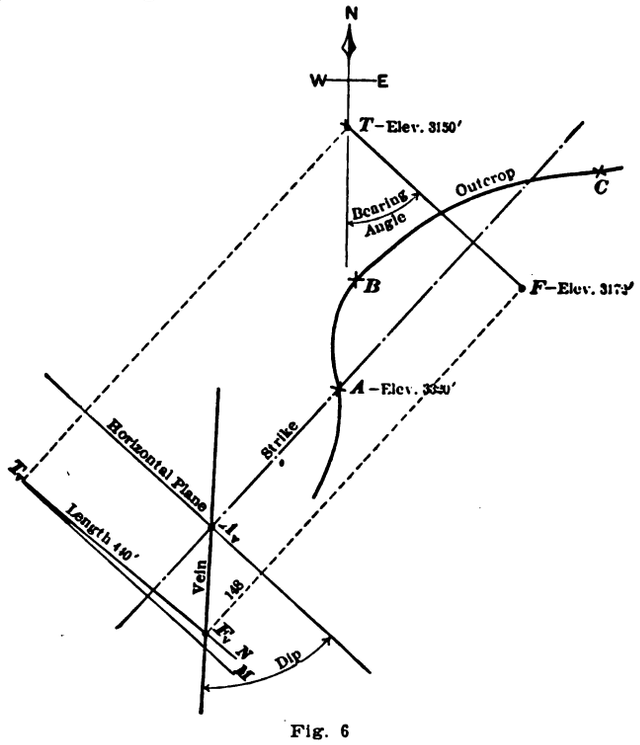

Fig. 6

V. LOCATION OF A TUNNEL.

Let A, Fig. 7, be the mouth of an inclined shaft and 1, 2, and 3 be drifts from it, both shaft and drifts following the vein. B is a vertical prospecting-shaft of a certain depth of an adjoining property. What will be the direction and length of the shortest drift from the bottom of B to pick up the vein and still keep on the "B" side of the line?

The drifts 1, 2, and 3 are presumably horizontal, and since they lie in the vein they are parallel to the strike. In the end-view they will appear as 1*v*, 2*v*, 3*v*, and will determine the end-view of the vein, the vertical shaft, B, appearing at B*v*B′*v*. A horizontal line from B′*v* will cut the vein at C*v*. The line XY through C*v*, parallel to the levels, is the plan-view of the intersection of the vein and a horizontal plane through B*v*, and any horizontal drift from B′*v* must intersect the vein somewhere along this line. In the plan-view the shortest drift would be BC′. But BC′ would run out of the property. BC therefore would be the limiting position of the drift to have it entirely on the "B" side of the line.

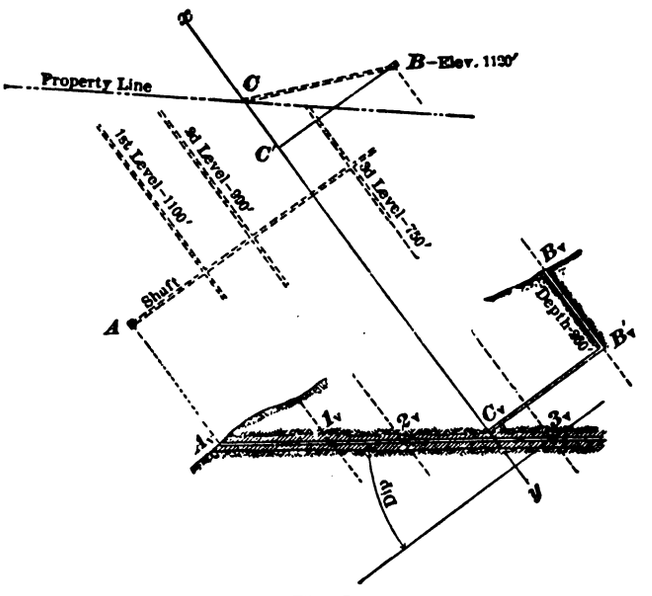

Fig. 7

VI. TO FIND THE BEARINGS OF A SHOOT.

Suppose we wish to find the bearings of a shoot in the vein ABC of Figs. 4 to 6. Let the shoot appear on the outcrop at B, Fig. 8, and have a pitch of 19° down toward the NE.

A side-view of the point B will show B*v* 140 ft. above the level of A. Any line through B with a pitch of 19° from the horizontal must cut the level of A at a distance of mn from the foot of the perpendicular through B*v*. All points in the vein on the same level as A lie somewhere along the strike-line. With B as a center and mn as a radius swing the arc XX, cutting the strike-line at some point, S. Connecting B and S, we have the bearing of the shoot. In the case shown we could expect the shoot to reappear on the outcrop at T. This construction

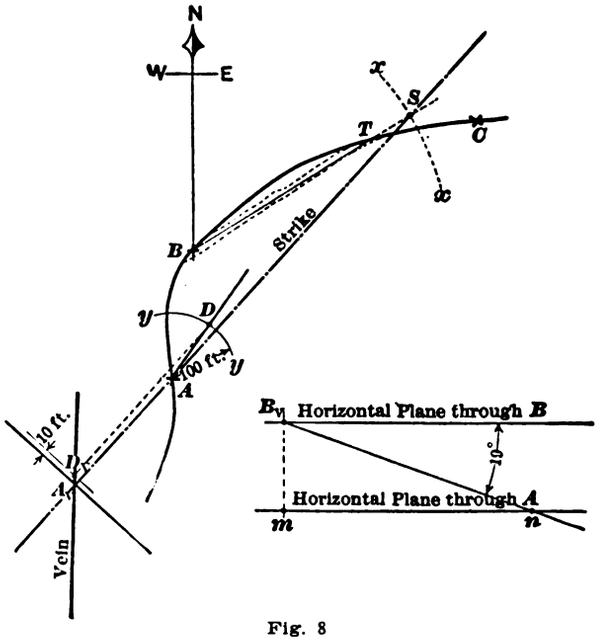

Fig. 8

might be used to locate a possible reappearance of a shoot in rough country overgrown with underbrush.

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A somewhat similar construction would give the bearing of a drift, lying in an inclined vein and itself inclined at some grade angle, say 10 per cent. Lay off to scale in an end-view a parallel 10 feet above a horizontal through A*v*. Project D*v*, the intersection of the parallel with the vein, to intersect an arc, yy, of 100 ft. radius swung from A, as at D. AD is the bearing desired.

VII. TO FIND THE THICKNESS OF A VEIN.

Given the outcrop and dip of the hanging and foot-wall, how thick is the vein and what is the strike?

Case 1.—Let the side-wall be vertical. Let the outcrops be as shown in the side-view of Fig. 9, their intersections with the ground or other horizontal plane being A*v* and B*v*. In the plan the side-wall appears as a line. Project A*v* and B*v* to A and B. Draw any line, yy, cutting the walls at C*v* and D*v*. Through C*v* and D*v* draw C*v*n and D*v*n$_1$, making the given dip angle with the horizontal. The perpendicular distance between these lines is the thickness of the vein. The strike would, of course, be perpendicular to the direction in which the dip is measured. A construction giving it more accurately would be as follows: Any plane through C*v* having the given dip angle must cut the horizontal plane at a distance mn from m. With C as a center and mn as a radius swing the arc XX. The strike-line, AA′, passes through A tangent to XX. BB′ is parallel to AA′, or it may be found in the same manner as AA′.

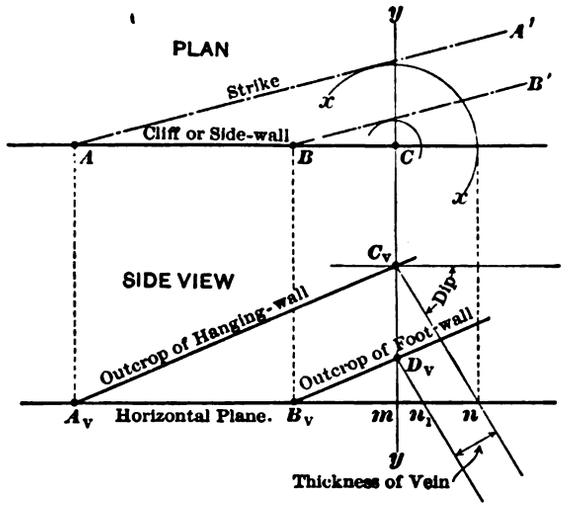

Fig. 9

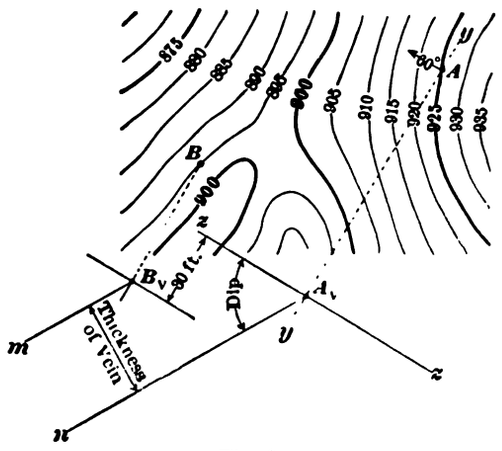

Fig. 9a

Case 2.—Let the surface be irregular, as, for instance, in Fig. 9a. Let the location and elevation of A and B and the angle and direction of dip be as shown. Draw a projection-line, yy, perpendicular to the direction of dip. Draw any line, zz, perpendicular to yy. Letting A*v* be the side-view of A, lay off the dip angle as shown. Lay off B*v* on a projecting-line parallel to yy at a distance of 30 ft. below zz. Through B*v* draw B*v*m parallel to A*v*n. The perpendicular distance between these lines is the thickness of the vein.

VIII. TO FIND THE LIMITS OF AN ORE-DUMP.

Given the location of a shaft or tunnel, A, Fig. 10, on a certain contour-level as shown, to find the outer limits of a dump formed by filling in on a level with A for a certain radius, say 200 ft.

With A as a center and AD=200 ft. swing an arc, BC, cutting the contour-level of A at B and C. The area between this arc and the contour through A is, of course, the top of the dump. Between B and C the side of the dump will extend down hill a varying distance, depending on the angle of rest of the material and the contour of the surface. Draw an auxiliary view showing a vertical section of the face of the dump. The sloping side appears as the indefinite line, D*v*E*v*, at an angle equal to that at which the material "hangs up," say 40°. Draw a series of levels, aa′, bb′, etc., corresponding to the contour-lines of the map, and to the same scale.

The side of the dump is a portion of a cone, with a vertical line through A as its axis. The top of the dump and the various levels, being parallel planes, cut the cone in a series of circles concentric with the axis. All points on the surface of the ground at an elevation of 980 ft. lie on the 980-ft. contour line, and all points on the face of the dump at 980 ft. elevation lie on an arc concentric with BC, and having a radius aa′ greater than that of the top. Wherever this arc meets the 980-ft. contour, as at 1,1, there is a point on both the face of the dump and the surface of the ground. The remaining points, as 2,2, etc., may be located by swinging the arcs from A or by measuring the increase in the radius, as bb′, etc., out from the arc BC, to cut the proper contour-line. Connecting the series of points so located, we have the completed outline of the dump.

There may be places where the edge does not cross a contour for some distance. Any uncertainty as to its location may be cleared up by interpolating on the ground and on the face of the dump, as shown on the shoulder of the knoll.

With the limits located and the surface-contours on the face drawn, calculation of the tonnage becomes a mere matter of mensuration. The area of the dump at each level is readily obtained from the contours with a planimeter. Each area will be bounded by a circular arc along the face of the dump and the corresponding irregular contour-line where the dump is in contact with the ground. The volume of each layer may be found by the end-area method or by the prismoidal formula.

IX. ORE-DUMP ON A PROPERTY-LINE.

In practice the problem might easily occur in the reverse form. Given a point, A, Fig 11, from which it is desired to fill, and a property-line, XXX.

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How much tonnage-capacity is there available in filling out to the line and extending, say, 200 ft., as before, wherever the property-line is not encountered? In the previous case the upper edge of the dump was regular and the outer one irregular. In this, the limits of a portion of the outer edge are set by the property-line, and the upper edge will, in consequence, be irregular.

As before, we have the crest of the dump starting out from B and C, Fig. 11, the two points on the contour through A at the given limiting distance of 200 ft. For a short distance the crest will be circular, with its center at A, and the outer edge will be found as before. It is evident, however, that the crest cannot swing out far before the property-line is encountered. To determine the side of the dump where it is affected by the side-line we may proceed as follows: Draw an auxiliary side-view. The level of the top, 990 ft., appears as shown, also the side of the dump and the parallels corresponding to the contour-levels of the map. For any points on the property-line, such as a and a′, which are on the 890-ft. level, it is evident that a vertical projection of the crest cannot come within the distance mn of a or a′ without having the dump overrun the side-line. From a and a′, then, swing arcs with mn as a radius. These arcs limit the position of the crest so far as a and a′ are concerned. Similarly, for b and b′ on the 900-ft. level, arcs swung with m′n′ as a radius locate the crest so far as b and b′ are concerned. Continuing this process for

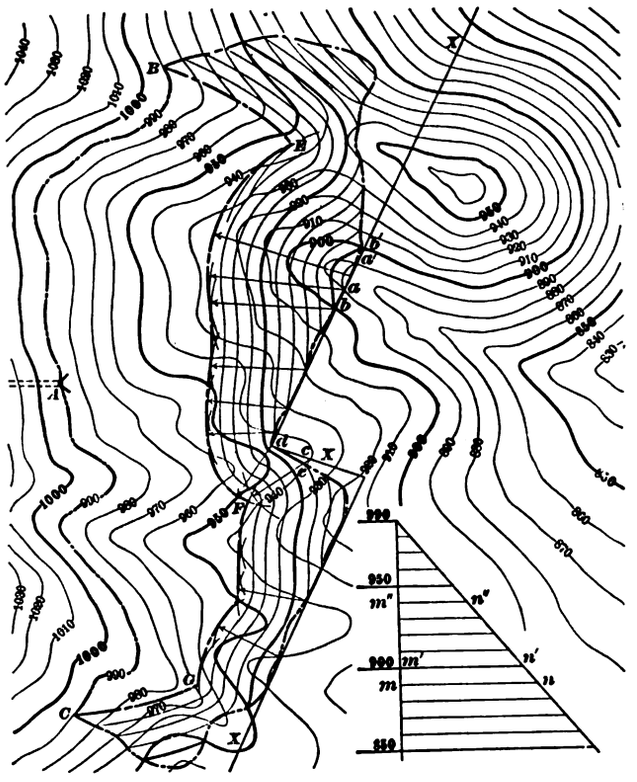

Fig. 11

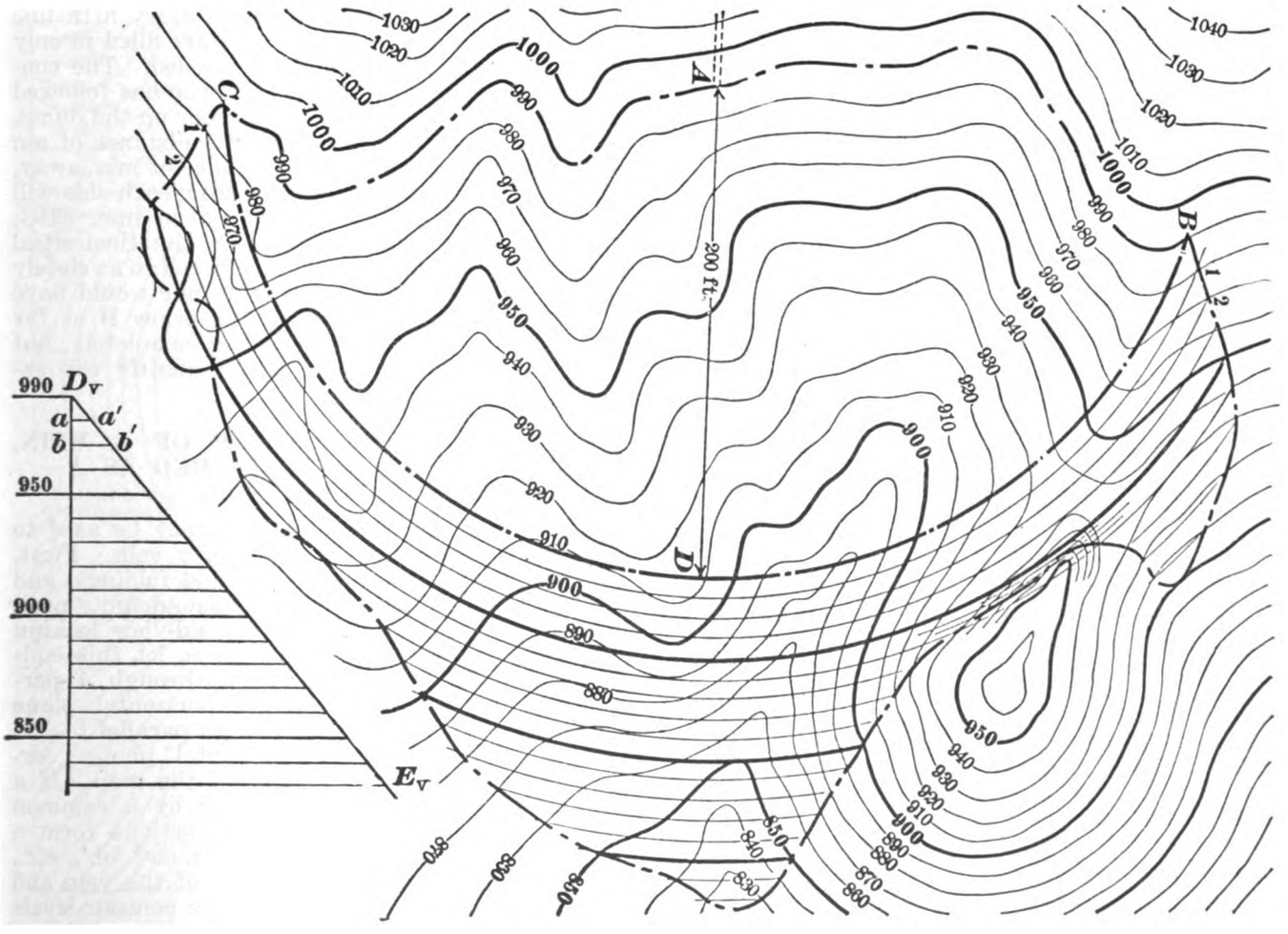

Fig. 10

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the intersection of each contour-line and the property-line, we obtain a series of arcs. The innermost arc, or the one toward the uphill side, limits the crest. Drawing a fair line tangent to the inside arcs, we have the crest EFG. An arc not used, such as that from c, indicates that as far as c is concerned the crest might come out to that arc; but the position of that from d, further in, shows that before the material could be filled out to the outer arc it would be over-running at d.

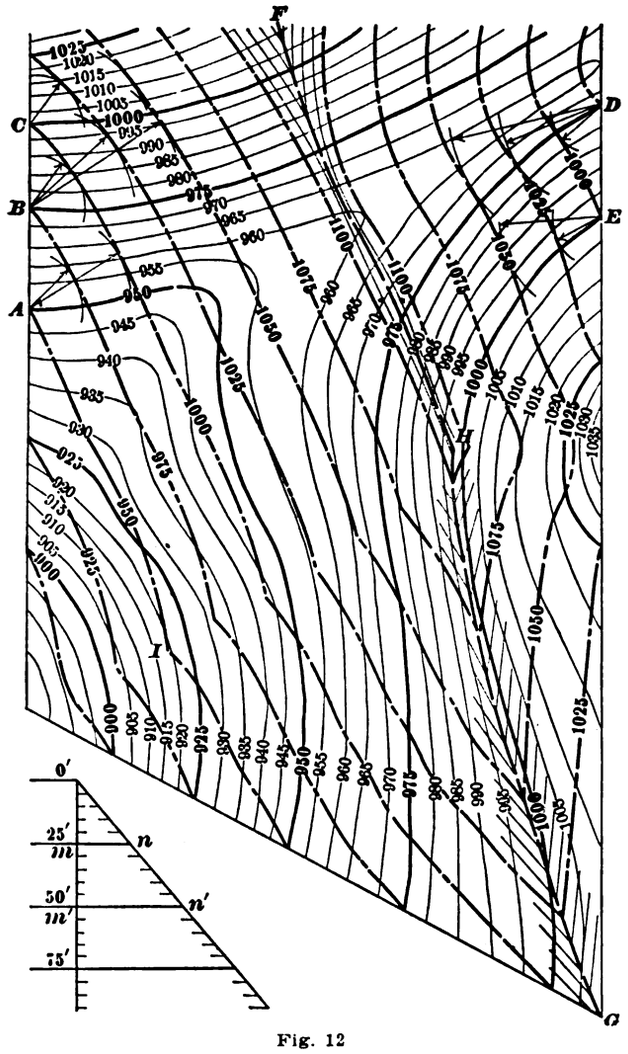

Fig. 12

While the line EFG is the farthest limit to which the crest can be carried, it does not follow that the foot of the dump will run out to the property line at all points. For instance, with the material falling away at an equal angle on all sides, it is evident that F cannot be pushed out far enough to cover the extreme corner without over-running on both sides. A portion of the corner and also any high points, such as those opposite E and G, will remain uncovered. The outline of the base is obtained, as in Fig. 10, by measuring out a distance from the crest equal to that from the vertical in the auxiliary view to the intersection of the sloping side of the given level. Thus, to locate the point e on the 940-ft. contour, cut that contour with an arc swung from F with a radius equal to m″n″, etc.

The contour-levels on the side of the dump corresponding to those of the ground will be a series of equidistant lines, the distance between them being equal to the difference between the successive lines m′n′, mn, etc., in the auxiliary figure. Wherever the dump-contour and the ground-contour for the same level intersect there is a point on the outer edge or foot of the dump.

X. LOCATION OF RIDGE FOR MAXIMUM CAPACITY

If it is desired to store a maximum tonnage on a given space the ore must rise from the boundary-line on all sides at the angle of rest of the material. If the ground is level the sides will meet in a point for a square or round area, in a straight horizontal ridge for a rectangular area, and in a straight, inclined ridge for an area bounded by non-parallel straight sides. When, however, the ground is broken and irregular, as is generally the case, the sloping sides will no longer be plane surfaces, and will meet in a sloping and irregular crest. It is an advantage to locate this crest in advance, for it is only when the material is deposited along this line that the maximum storage-capacity of the ground is utilized. This crest, then, would indicate the proper location for a dumping-trestle, for material can be filled in along this line until it begins to over-run on both sides at the same time.

Let it be desired to cover the tract shown in Fig. 12, from some point, such as F, on the upper side. Locate F and the course of a dumping-trestle from which the entire tract may be filled in. Use the auxiliary side-view as before the work in from the boundary-lines, the first radii being mn, as at A,B,C, the second m′n′, etc. Here every fifth line is used, and the intermediate ones are filled in only along the crest where they are needed. The construction used will be clear to one who has followed the previous two problems. A contour on the dump, starting from C, would pass B at a distance of mn away, and would pass A at a distance of m′n′ away, etc. The dump-contours located from each side will be found to intersect along a broken line, FHG, which is the crest. This line is the theoretical course for a trestle and may be adhered to as closely as is deemed desirable. A slight spur would have to be run to the left from a little below H as far as I to fill in the left-hand corner completely, but the capacity gained would hardly justify the expense.

XI. TO PLOT THE OUTCROP OF A VEIN, WHICH MAY BE CONSIDERED AS A PLANE SURFACE.

Descriptive geometry methods may be used to determine the probable outcrop of a vein. First, let the vein be free from faults and foldings, and the strike and dip be known for some definite position, as A in Fig. 13. Draw an end-view looking up the strike-line. For convenience, let this end-view be drawn with the line XX through A perpendicular to the strike as the horizontal plane through A. Let the series of lines parallel to XX be the end views of the horizontal planes corresponding to the contour-lines of the map. If a number of parallel planes be cut by a common secant plane, the resulting intersections form a series of parallel lines. The lines aa′, bb′, etc., projected up from the intersection of the vein and the various levels, are in reality the contour-levels for the vein, which in this case becomes a series of

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parallel lines. Wherever, therefore, the line AA′ and the 710-ft. surface-contour cross, we have a point in the vein and on the surface of the ground; that is, on the outcrop. Similarly, the intersections of the line aa′ and the 700-ft. contour give points on the outcrop. By locating these intersections for each level and connecting them up we have the outcrop. This method can be used only for comparatively small areas where the vein may be considered as a plane surface. When the vein is faulted to any great extent the treatment becomes complicated, so much as to preclude its consideration in this paper. When the vein is continuous but folded, as, for instance, a coal-seam, a method of determining the outcrop may be used, which is illustrated in Figs. 14 to 16.

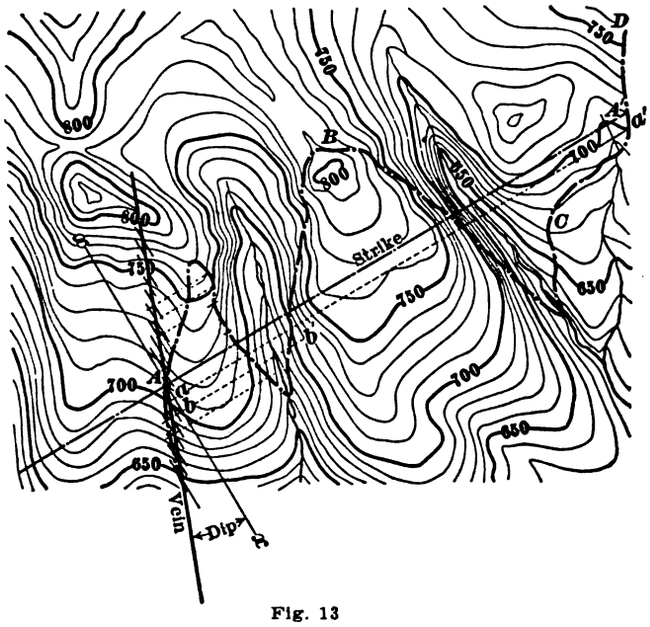

Fig. 13

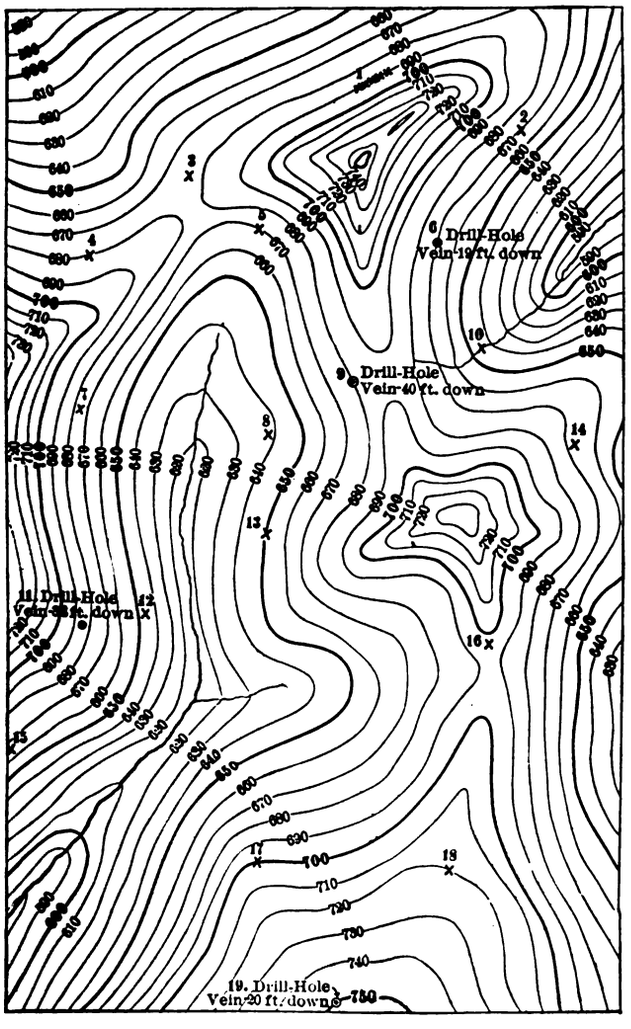

Fig. 14

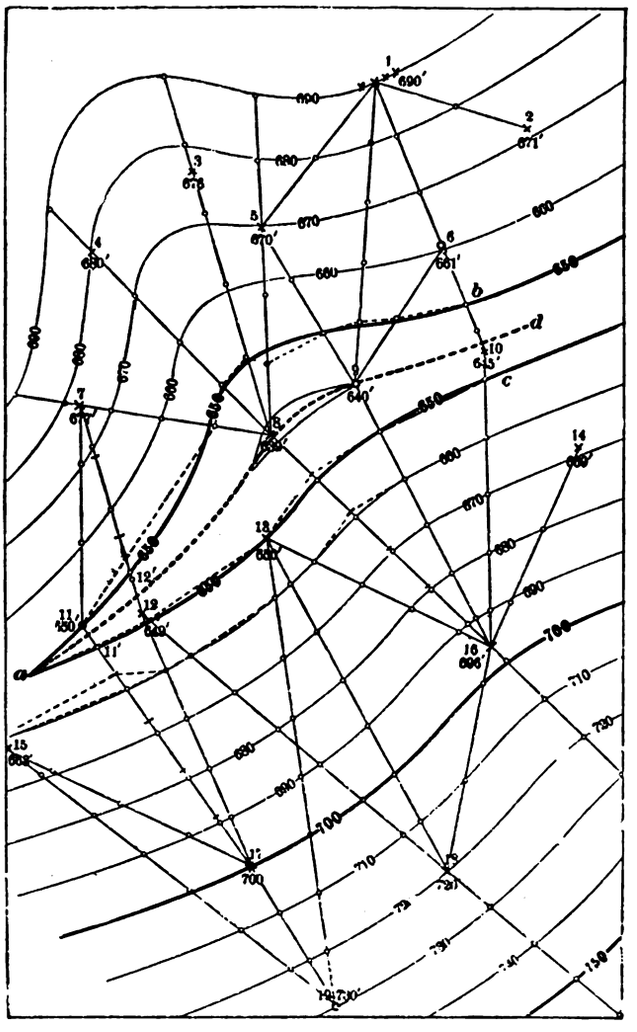

Fig. 15

XII. TO DETERMINE THE OUTCROP OF A FOLDED VEIN OR SEAM.

Let Fig. 14 be a contour-map of an area on which an irregular outcrop has been partly located, as, for instance, at the stations marked with an X. At various other points, as 6, 9, 11, 19, drill-holes have been sunk and the seam located at the depths noted. The form of the folded seam may be determined if we can establish its contour-lines corresponding to those on the surface, and where these seam-contours intersect those of the surface of equal elevation we have points on the outcrop.

For the sake of clearness, we will gather all the information available into a separate illustration, Fig 15. This gives us stations 1 to 19, with the elevations of the surface of the seam for each, as noted. A general inspection shows that there is a

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syncline near the middle of the tract, the depression running NE-SW., since stations 8, 9, 10, 11, 12, 13 are all at nearly the same level. Assuming, for a start, that the dip from the higher points, as 16, 17, 18, etc., toward the depression is substantially constant, lines may be drawn connecting the stations, and the elevations at the contour intervals may be interpolated, as on lines 13-16 and 13-18. Where necessary the levels may be extrapolated, as on the extensions of lines 8-16 and 12-18, but points so located are, of course, not so reliable as the interpolations. They aid, however, in obtaining the general direction of the contours, and as the seam has been eroded at these points, great accuracy is not needed.

In this way a series of points of equal elevation are obtained for both sides of the depression. The auxiliary lines, such as 12-18 and 9-16, which are substantially perpendicular to the depression, will be steeper, cross more contours, and give more reliable interpolations than lines more nearly parallel. In interpolating with these lines care should be used that they connect stations on the same side of the depression, as, for instance, 11-17. Station 12 is probably on the same side as 17, but 11 may be, and in fact is, on the other side. This may be determined as follows: The points on the 650 and 660-ft. levels line up well except those marked with a cross-bar on lines 11-17 and 7-12. Rejecting these two sets and connecting the others, we have the broken lines ab and ac, which give the general location of two 650-ft. contours. Assuming that the trough lies midway between these lines, we obtain the dotted line ad as its location. If now we take a new point, 11′, on the opposite side of ad and at the same distance from it, and interpolate the line 11′-17, we obtain points agreeing well with the others. In like manner, a new set of elevations may be obtained from the lines 7-12, 8-16 and 6-10.

Connecting the various points of equal elevation by curves, we obtain seam-contours, as shown in Fig. 15. If these seam-contours of Fig. 15 be superimposed on the surface-contours of Fig. 14, we will have a series of points where contours of equal elevation intersect, which will determine the irregular outcrops, ABCD and EF of Fig. 16. The shaded portions indicate the areas under which the seam lies. Elsewhere it has weathered away. The probable depth of the seam at any poin may be obtained by subtracting the elevation of the seam from that of the surface, as indicated by the respective contours for that point. For instance, at G the depth is 690 ft. less 655 ft., or 35 ft.

The value of this contour-method, where the outcrop is overgrown or obscured by soil, is obvious. An excellent example of its application will be found in the Masontown Folio of the U. S. Geological Survey, where structure-contours have been drawn on the upper surface of the Pittsburgh coal-seam, showing its elevation above sea-level. Over large portions of this area the coal has been eroded. Where observations were obtainable a stratum was observed to maintain a substantially constant interval below. This lower stratum was but little eroded, and was used to obtain the theoretical position of the eroded portion of the coal-seam. A number of hills, high enough to pierce the seam thus located, were found to contain portions where its presence would not otherwise have been suspected. This indirect method of using parallel strata was also utilized where the seam lay too deep for observation direct, in this case the stratum being above the seam.

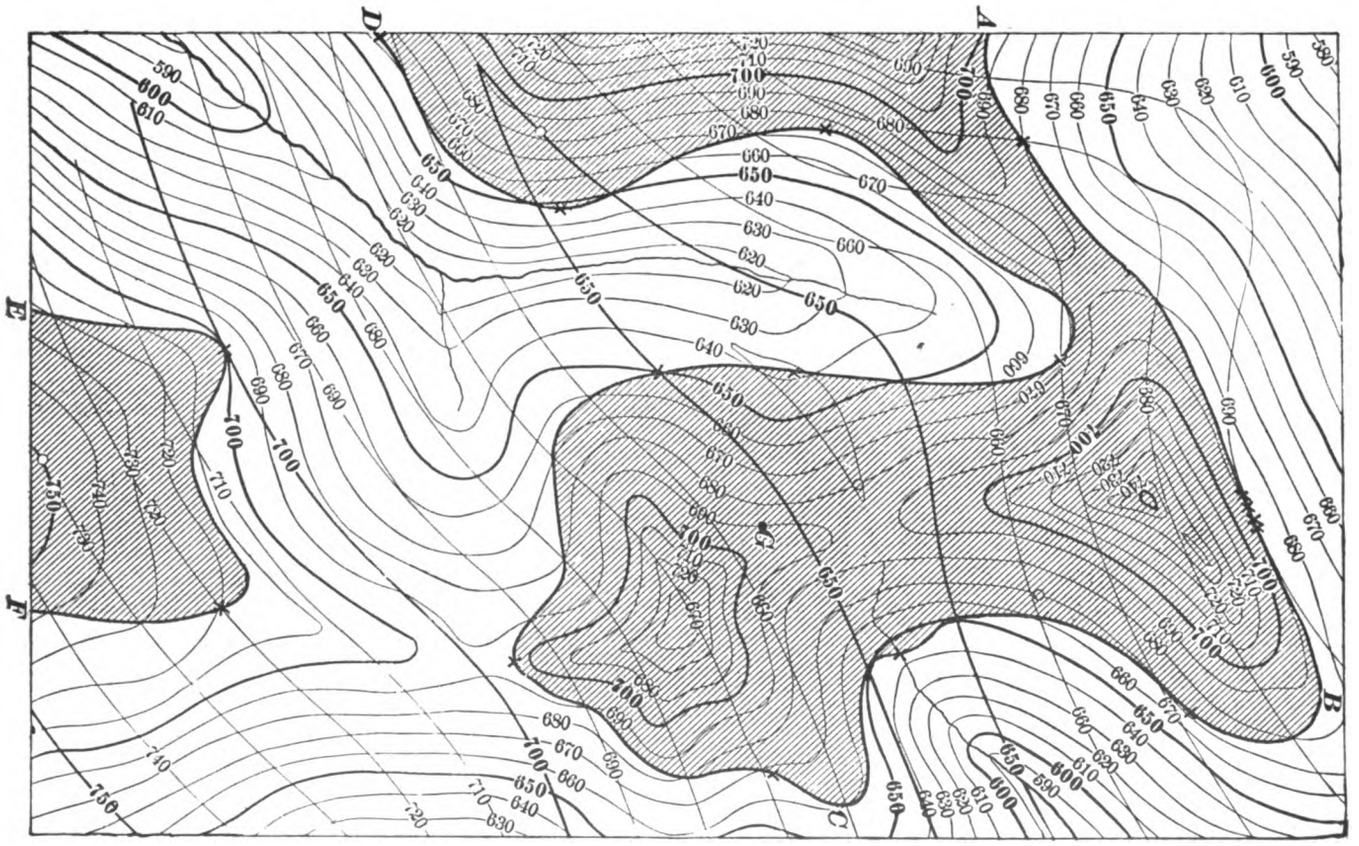

Fig. 16

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Fig. 17 illustrates how parallel strata may be used to corroborate and supplement direct data. This use of parallel strata has been described by M. R. Campbell in T. A. I. M. E., Vol. 26, p. 298.

The direct data of the upper section, Fig. 17, give only three points on the seam, which is everywhere obscured or eroded. If the intervals beween I. and II., and II. and III. in the columnar section be established, and if I. and III. be located at various outcrops, as shown in the lower section, then the intervals may be set off from these outcroppings, and will greatly increase our information on the surface to be contoured.

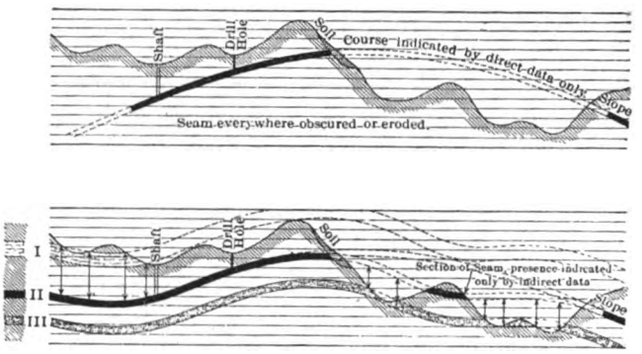


Fig. 17

Determination of the Meridian

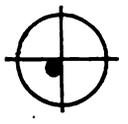
The true meridian may be determined by a direct observation on the sun by the single-altitude method.

In order to make an observation on the sun it is necessary to have a prismatic eyepiece with a colored shade.

Description of the Single Altitude Method by Direct Observation on the Sun

To take the observation, set up the transit over some station, and with the verniers set at zero, sight to some defined station or mark. Unscrew eyepiece cap and screw on prismatic eyepiece.

Loosen the upper clamp, and with the telescope direct, foresight on the sun, bringing its image tangent to the cross-hairs in the upper right-hand quadrant as shown in Fig. 18. Record the time, horizontal and vertical angles. Then bring the image of the sun tangent to the cross-hairs in the lower left-hand quadrant as shown in Fig. 19. Record the time, horizontal and vertical angles. Call this operation Set I.



Figs. 18 and 19

Loosen the upper clamp and with the telescope reversed, take two readings as before but with image of sun tangent to cross-hairs as shown in Fig. 20, Set II.

Complete Sets III and IV as shown in Fig. 20.

Mark.	Telescope direct		
Sun.	Telescope direct		Set I
Sun.	Telescope direct		
Sun.	Telescope reversed		Set II
Sun.	Telescope reversed		
Sun.	Telescope reversed		Set III
Sun.	Telescope reversed		
Sun.	Telescope direct		Set IV
Sun.	Telescope direct		
Mark.	Telescope direct		

Fig 20

Fig. 20 shows program for making a complete observation.

The mean time, the mean horizontal angle, and the mean vertical angle as found from results will be used in the computations.

The formula for computing the azimuth is as follows:

$$\text{Cotan } \tfrac{1}{2} A = \sqrt{\text{Sec S, Sec (S} - \text{P), Sin (S} - \text{H), Sin (S} - \text{L).}}$$

Where A is the angle between the south and sun;

P is the north polar distance of sun (90° ± declination);
H is the altitude of sun, corrected for refraction;
L is the latitude of station;
S is ½ (P + H + L).

Computations are most conveniently made on following form, Fig. 21.

Practical suggestions:

The observation should be made when the altitude of the sun is near 30 degrees for best results, and the best time of day is between 8 to 10 A. M. and 2 to 4 P. M.

With eight pointings on the sun in manner described as above, instrumental errors, error in finding center of sun as judged by eye, are eliminated.

Time between readings should not vary above 1 minute, or should be taken as near together as possible in each set.

Instead of setting verniers at zero, at beginning of observation, same azimuth may be used as carried on a line of survey between two traverse stations.

Instrument should be in good adjustment and focus sharp.

With careful work an observation will give a mean result with an error much less than one minute.

To take check-observations, one should be taken in the morning and one in the afternoon, or on different days.

A simpler formula used by many progressive engineers is

$$\text{Cos Bearing} = \frac{\text{Sin Decl}}{\text{Cos Lat Cos Alt}} - \text{Tan Lat Tan Alt}$$

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AZIMUTH COMPUTATION FROM SOLAR OBSERVATIONS

Latitude,———°———'———" N.; Longitude,———°———'———" E.

Survey,——————— Station occupied,——————— Date,———————, 19—

Cot. ½ A = $\sqrt{\text{Sec. S, Sec. (S — P), Sin. (S — H), Sin. (S — L).}}$

Where A is the angle between South and Sun.
P is the North polar distance of Sun (90° ± Declination.)
H is the altitude of the Sun, corrected for refraction.
L is the Latitude of Station.
S is ½ (P + H + L).

Description of Mark:

	SET I (O| Time — |O Time)		SET II (O| Time — |O Time)		SET III (|O Time — O| Time)		SET IV (O| Time — |O Time)	
	Horizontal Angles	Vertical Angles	Horizontal Angles	Vertical Angles	Horizontal Angles	Vertical Angles	Horizontal Angles	Vertical Angles
Sums								
Mean		—		—		—		—
Parallax and refraction								
True altitude = H								

Local M. Time of observation.....
Longitude in time.....

Greenwich M. Time of observation.....
Interval from Gr. Noon.....
Hourly difference.....
Total difference.....
App. Declination at Gr. Noon.....

Corrected Declination.....
90° ±.....

N. Polar Distance = P.....
H.....
L.....

2 S.....

S.....
P.....

S — P.....
S.....
H.....

S — H.....
S.....
L.....

S — L.....

Log. Sec. S.....
Log. Sec. S — P.....
Log. Sin. S — H.....
Log. Sin. S — L.....

Log. Cotan.² ½ A.....
Log. Cotan. ½ A.....
½ A.....
A.....
Azimuth of Sun.....
Angle Sun to Mark.....

Azimuth Station to Mark.....
Azimuth, Set II.....
Azimuth, Set III.....
Azimuth, Set IV.....

Divide by.....4

Average Azimuth Station to Mark.....
Bearing Station to Mark.....

In A. M. Azimuth of Sun is 360° minus A.
In P. M. Azimuth of Sun is A.
If Mark is to left of sun, horizontal angle is to be subtracted; if to right, it is to be added.
Magnetic Declination is———°———'

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Laying off Mine Curves

The degree of accuracy in laying off curves in the mine may depend upon the importance of the location, or possibly upon the means at hand. Transportation has now become so vital a factor in the attaining of large outputs that the importance of smooth easy transitions between tangents is clearly understood, and well laid out curves have become a standard requirement at all carefully managed mines.

Frequently curves are laid off in mines by approximate methods, such as the set-in-the-dark method; by board template, 10 feet long, with a middle ordinate; string and offset method; graphic method, etc. The most dependable method is with the transit, using offsets and deflection angles. Its use insures regularity of curvature, particularly for curves of long radii. In addition to the two tables showing curve data, two methods of doing the work are here shown.

To Locate a Curve With a Tape by Offsets

Since 10 foot chords are a convenient length, we will assume this length to apply in the problem to be assumed. The tangent offset, a, for a 10 foot chord, c, and radius, R, is found by means of the formula,

$$a = \frac{c^2}{2R} = \frac{10 \times 10}{2R} = \frac{50}{R} \quad (1)$$

Having determined the value of a, the procedure will be as follows: (see the figure; also see Table A for values of a, given for various chord lengths and radii).

(a) Locate the point of curve, P.C., by measuring back from the frog a distance equal to twice the gage times the frog number (2gn).

(b) Measure 10 feet from P.C. on the straight rail; offset the distance, a, and thereby locate B, which is also 10 feet from P.C.

(c) Prolong the line P.C. — B 10 feet more to D; offset the distance, 2a, to C.

(d) Locate E and points beyond in the same manner as C.

The number of chords to be located is determined by the length of curve, L. This may be found by use of the formula:

$$L = \frac{100\ I}{D} \quad (2) \quad \text{where}$$

I = intersection angle of tangents

$$D = \text{degree of curve} = \frac{5730}{R} \quad (3)$$

Assuming for example, a 50 foot radius curve and the two connecting entries to be running at right angles, we have,

$$I = 90 \text{ deg.}$$

$$D = \frac{5730}{50} = 114.6$$

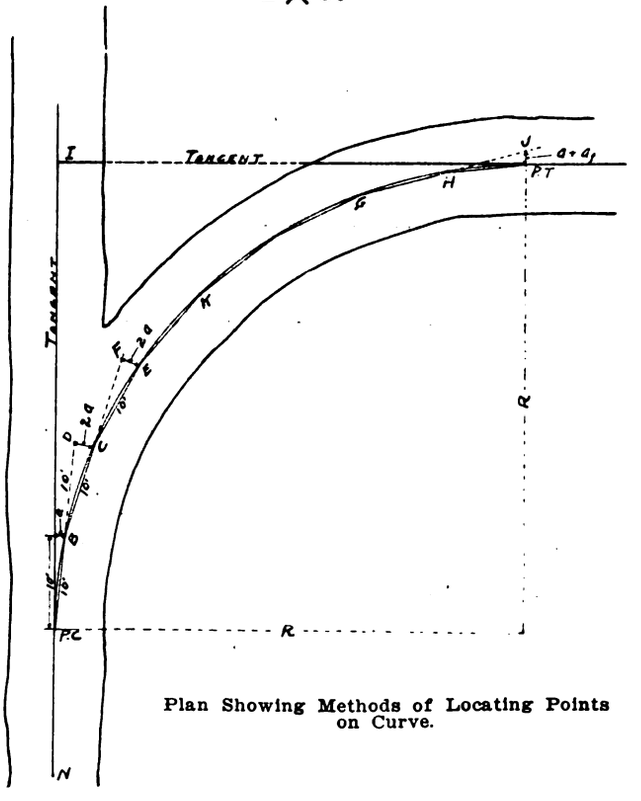
$$\text{Then } L = \frac{100 \times 90}{114.6} = 78.5 \text{ feet}$$

There would then be seven full chords of 10 feet and a final sub-chord of 8.5 feet. Then offset, a_f, for the sub-chord is found by formula (1) to be,

$$a_f = \frac{8.5 \times 8.5}{2 \times 50} = .72 \text{ ft.} = 8.64 \text{ inches}$$

The offset for a full chord of 10 ft., according to the same formula, or according to Table A, is

$$a = \frac{10 \times 10}{2 \times 50} = 1 \text{ ft.}$$



Plan Showing Methods of Locating Points on Curve.

To locate the tangent point, P.T., of curve, prolong line GH a distance of 8.5 feet to the point J. Measure the sum of the two offsets, $a + a_f = 12 + 8.64 = 20.64$ inches at right angles to line GHJ and the result will be the P.T. or end of the curve.

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To Locate a Curve With a Transit by Deflection Angles and Offsets

Assume once more a curve of 50 foot radius and 10 foot chords. Proceed as follows:

(a) Set the transit at station P.C.

(b) Set the vernier at O.

(c) Backsight on Station N (last station) and reverse.

(d) Set off the proper deflection angle, taken from Table A for a radius of 50 ft. and a chord distance of 10 ft.

(e) Measure off P.C. — B = 10 ft.

(f) Prolong line P.C. — B 10 feet to D and locate point C on curve at distance, 2a, from D (see Table A for value of a).

(g) Set off a total deflection angle of three times the initial deflection angle = $3 \times 5° - 44' = 17° - 12'$.

(h) Measure CE = 10 ft.

(i) Locate K by turning off four times the initial deflection angle, and measuring 10 ft. from E.

It now becomes necessary to transfer transit to station K. Before moving the transit, unclamp the lower motion. After setting up at K, proceed as follows:

(j) Check the vernier to be sure the plates have not moved and backsight on station P.C. Plunge the telescope and bring the vernier to O reading.

(k) From station K, locate the remaining chords up to H in exactly the same manner as was used at station P.C.

The number of chords is derived as already explained in the first method of laying out a curve, and is found to be seven full chords and a final sub-chord of 8.5 ft., reaching from H to the end of curve, or P.T. The formula for finding the sub-deflection angle of a sub-chord is,

$$\frac{d}{2} = \frac{cD}{200}, \text{ where}$$

$$\frac{d}{2} = \text{sub-deflection angle}$$

$$c = \text{sub-chord}$$

$$D = \text{degree of curve}$$

$$\text{then } \frac{d}{2} = \frac{8.5 \times 114.6}{200} = 4.87° = 4° - 52'.$$

$4° - 52'$ is therefore the final set off on the vernier to bring it on sight with the P.T., which is then definitely located by measuring 8.5 ft. from H.

Since angle I — P.C. — P.T. = angle I — P.T. — P.C. = ½ I, a check on the mathematical work is furnished. In the problem here assumed, the intersection angle I is 90 deg.; ½ I is then equal to 45 deg. Adding 7 times the angle $5° - 44'$ plus the final sub-deflection angle of $4° - 52'$, we have a total of 45 deg., which proves our work.

TABLE A. DEFLECTION ANGLES AND OFFSETS FOR CURVES OF SMALL RADIUS

RADIUS	10′		20′		30′		40′		50′		60′		70′	
CHORD	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a
5 ft.	14°29′	15″	7°11′	7½″	4°47′	5″	3°35′	3¾″	2°52′	3″	2°23′	2½″	2°03′	2 1/7″
10 ft.	30°00′	60″	14°29′	30 ″	9°36′	20″	7°11′	15 ″	5°44′	12″	4°47′	10 ″	4°06′	8 4/7″
15 ft.	48°35′	135″	22°01′	67½″	14°29′	45″	10°48′	33¾″	8°38′	27″	7°11′	22½″	6°09′	19 2/7″
20 ft.			30°00′	120 ″	19°28′	80″	14°29′	60 ″	11°32′	48″	9°36′	40 ″	8°13′	34 2/7″
25 ft.			38°41′	187½″	24°37′	125″	18°13′	93¾″	14°29′	75″	12°01′	62½″	10°17′	53 4/7″
30 ft.					30°00′	180″	22°01′	135 ″	17°27′	108″	14°29′	90 ″	12°22′	77 1/7″
35 ft.					35°41′	245″	25°57′	183¾″	20°29′	147″	16°57′	122½″	14°29′	105 ″
40 ft.							30°00′	240 ″	23°35′	192″	19°28′	160 ″	16°36′	137 1/7″
45 ft.							34°14′	303¾″	26°45′	243″	22°01′	202½″	18°45′	173 4/7″
50 ft.									30°00′	300″	24°37′	250 ″	20°55′	214 2/7″

RADIUS	80′		90′		100′		125′		150′		200′		250′		300′	
CHORD	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a	Deflect. Angle	Offset a
5 ft.	1°47′	1⅞″	1°35′	1⅔″	1°26′	1½″	1°09′	1⅕″	0°57′	1″	0°43′	¾″	0°34′	⅗″	0°29′	½″
10 ft.	3°35′	7½″	3°11′	6⅔″	2°52′	6 ″	2°17′	4⅘″	1°54′	4″	1°26′	3 ″	1°08′	2⅖″	0°57′	2 ″
15 ft.	5°23′	16⅞″	4°47′	15 ″	4°18′	13½″	3°26′	10⅘″	2°52′	9″	2°09′	6¾″	1°43′	5⅖″	1°26′	4½″
20 ft.	7°11′	30 ″	6°23′	26⅔″	5°44′	24 ″	4°35′	19⅕″	3°49′	16″	2°52′	12 ″	2°17′	9⅗″	1°54′	8 ″
25 ft.	8°59′	46⅞″	7°59′	41⅔″	7°11′	37½″	5°44′	30 ″	4°47′	25″	3°35′	18¾″	2°52′	15 ″	2°23′	12½″
30 ft.	10°48′	67½″	9°36′	60 ″	8°38′	54 ″	6°53′	43⅕″	5°44′	36″	4°18′	27 ″	3°26′	21⅗″	2°52′	18 ″
35 ft.	12°38′	91⅞″	11°13′	81⅔″	10°05′	73½″	8°03′	58⅘″	6°42′	49″	5°01′	36¾″	4°01′	29⅖″	3°21′	24½″
40 ft.	14°29′	120 ″	12°50′	106⅔″	11°32′	96 ″	9°12′	76⅘″	7°40′	64″	5°44′	48 ″	4°35′	38⅖″	3°49′	32 ″
45 ft.	16°20′	151⅞″	14°29′	135 ″	13°00′	121½″	10°22′	97⅕″	8°38′	81″	6°27′	60¾″	5°10′	48⅗″	4°18′	40½″
50 ft.	18°13′	187½″	16°08′	166⅔″	14°29′	150 ″	11°32′	120 ″	9°36′	100″	7°11′	75 ″	5°44′	60 ″	4°47′	50 ″

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Methods of Earthwork Calculations*

The following methods are those commonly used in railroad work for these calculations and the limitations of each class as given have been proven by the calculation of millions of tons of earthwork in practice and checked by subsequent excavation. These methods are applicable to all tonnage calculations likely to be encountered in mining practice, whether on the surface or underground.

In all of the examples shown the cuts will have a base of 20 feet and a side slope of 1 to 1, and the fills will have a base of 18 feet with a side slope of 1½ to 1.

Class I. Average End Area Method. This method is used where there is no unusual warping, or irregularity to the surface of the ground, and the larger end area is not more than four times the smaller end area. This method is to average the areas and multiply by the length of the mass, and if desired in cubic yards divide by 27 (no. of cu. ft. in 1 cu. yd.)

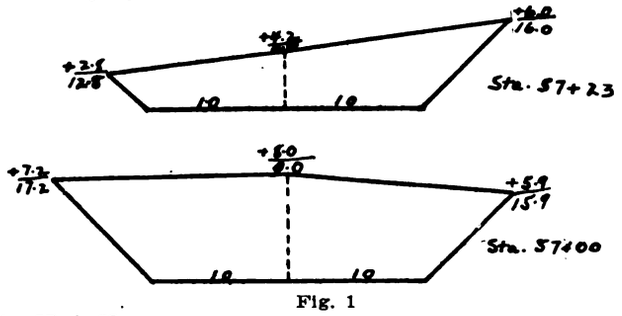

Fig. 1

Sta. 57 + 23

$$\text{Area} = \frac{10(2.8 + 6) + 4.2(12.8 + 16)}{2}$$

$$= 104.48 \text{ sq. ft.}$$

Sta. 57 + 00

$$\text{Area} = \frac{10(7.2 + 5.9) + 8(17.2 + 15.9)}{2}$$

$$= 197.90 \text{ sq. ft.}$$

$$\text{Vol.} = \frac{(104.48 + 197.90) \times 23}{2}$$

$$= 3477.37 \text{ cu. ft.} = 128.79 \text{ cu. yds.}$$

Class II. Where there is an unusually irregular surface, or the larger end area is more than four times the smaller, then compute the volume by the Prismoidal Formula, which is as follows: Add four times the middle area to the end areas and multiply by one-sixth of the length.

The middle section is constructed by interpolation, as shown by the figures in the circles.

Sta. 96 + 25

End Area = (Solved by series of triangles and trapezoids)

	$\frac{3 \times 4.1}{2}$	= 6.15
	$\frac{9.6 \times 7.1}{2}$	= 34.08
	$\frac{9.6 + 9.5}{2} \times 7$	= 66.85
	$\frac{9.5 + 11.3}{2} \times 8$	= 83.20
	$\frac{11.3 \times 16.1}{2}$	= 90.97
	$\frac{2 \times 14.1}{2}$	= 14.10
End Area		= 295.35

Middle Area	$\frac{3 \times 3.7}{2}$	= 5.55
	$\frac{5.65 \times 6.7}{2}$	= 18.98
	$\frac{5.65 + 4.75}{2} \times 7$	= 36.40
	$\frac{4.75 + 6.5}{2} \times 8$	= 45.00
	$\frac{6.5 \times 10.4}{2}$	= 33.80
	$\frac{2 \times 8.4}{2}$	= 8.40
Middle Area		= 148.13

Sta. 96 + 08

$$\text{End Area} = \frac{10(3.3 + 2.7)}{2} = 30.00$$

End Area..... = 295.30
4times Middle Area = 592.32
End Area..... = 30.00

= 917.62 X 17 = 15600.4 cu. ft.
= 577.92 cu. yds.

By the Average End Area Method result would be 102.42 cu. yds.

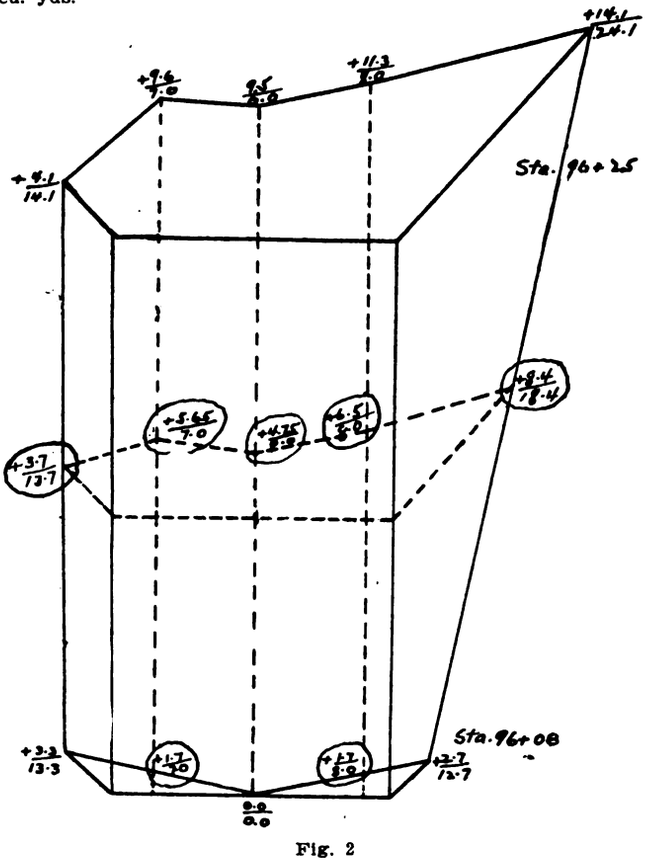

Fig. 2

Class III. Where cuts and fills come to grade and have no area at one end, or where embankment ends, as at bridge openings, use the Wedge and Two Pyramid Method. The cubic contents of pyramids are found by multiplying the area of the base by one-third the height, and wedges (as we use them) by multiplying the area of the base by one-half the height. In the wedges take the average height of fill multiplied by the width of road

*As Used on O. & W. R. R.

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bed for the area of the base. This is to be used only when one end of the mass has no area. If the small end has some area the prismoidal formula applies.

INTERPOLATE SIDE HEIGHTS OF WEDGE

$$\text{Average height} = \frac{1.5 + 1.2 + 2.6}{3} = 1.76$$

$$1.76 \times 18 = 31.68 = \text{area of base}$$

$$\text{Vol. wedge} = 31.68 \times \frac{13}{2} = 205.92 \text{ cu. ft.}$$

$$\text{Vol. of pyramids} = \left(\frac{1.5 \times 2.4}{2} + \frac{2.6 \times 5.1}{2}\right) \times \frac{13}{3} = 36.53 \text{ cu. ft.}$$

Then Volume = 205.92 + 36.53 = 242.45 cu. ft.
= 8.98 cu. yds.

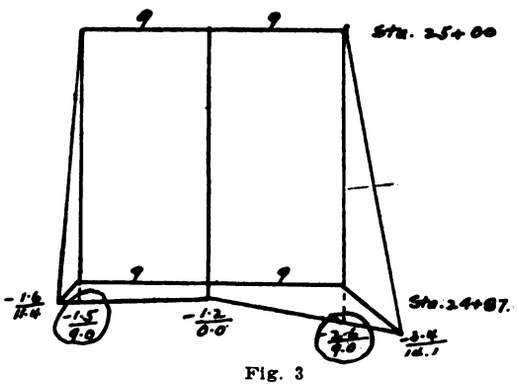

Fig. 3

Class IV. Where cuts and fills meet on the bias of the surface and grade point is met with on one side before it is on the other, the Simple Pyramid Method should be used. Multiply the end area (or base) by one-third the length (or perpendicular). Unless there is a change in the surface lines between the points, it is only necessary to take cross sections at the point where the side lines of the roadbed come to grade. But all quantities in cuts must be figured with the apex at grade 10 feet out from the center, while quantities in fills must be figured with apex at grade 9 feet out.

SPECIFIC VOLUME OF ROCKS AND MINERALS*

Material	Weight per Cu. Ft.	Cu. Ft. per Ton of 2000 Lbs.
Quartz	165.62	12.07
Andesite	165.62	12.07
Granite	162.62	12.30
Diabase	181.25	11.30
Diorite	171.87	11.63
Dolomite	178.12	11.23
Slate	162.62	12.07
Sandstones	162.50	12.30
Rhyolite	156.25	12.80
Arsenical Pyrites	371.87	5.37
Chalcopyrite	262.50	7.61
Bornite	321.87	6.21
Malachite	247.50	8.04
Azurite	237.50	8.42
Chrysocolla	132.50	15.09
Magnetite	375.62	6.33
Hematite	306.25	6.53
Pyrite	312.50	6.40
Galena	468.75	4.27
Cinnabar	531.25	3.76
Zinc-blende	253.12	7.90
Tin Oxide	418.75	4.77

Example—To find the number of cubic feet per ton of an ore containing 94% quartz, 4% iron pyrite, 2% galena:

Quartz	0.94 x 12.07 =	11.34
Pyrite	0.94 x 6.40 =	0.25
Galena	0.02 x 4.27 =	0.08
		11.67

Making allowance for porosity, this ore may be considered to occupy 12 to 13 ft. of space per ton.

*Janin's Engineer's Examination and Report Book.

SPECIMEN FORM FOR CONTRACTING DRILLING

(Information Desired by Manufacturers)

When inquiring about the cost of Diamond Core Drilling give the following information:

Definite location of work.....
.....

Name of nearest railroad and distance from property.....
.....

Distance and character of nearest accommodations for crew—.
.....

Are teams available and at what price per day?.....

Is fuel available at prospect?.....

What kind and at what price?.....

What mineral is to be prospected for?.....

If underground, state depth and available working space and whether there is sufficient power available at location of drill. (For efficient service underground we should have 90 pounds of air at the drill.)
.....

If electric current is used, please state whether alternating or direct, and voltage, phase and number of cycles.....
.....

Are holes to be vertical or angle?.....

If angle, state degree of angle from the horizontal.....

Character and probable depth of overburden.....

Character and kind of rock to be drilled.....

Is formation solid or broken?.....

Probable number of holes.....

Greatest depth in any one hole.....

Minimum amount of footage you guarantee.....

Distance and nature of nearest water supply.....
.....

When do you wish work begun?.....
.....

Will you have superintendent or representative at the location?
.....

Do you wish a geological report?.....

Do you wish our geologist to select location for drill holes and direct the drilling?.....

Do you wish us to be responsible for proper classification of materials, or only drillman's report?.....

Do you wish us to do any assaying?.....

Do you wish us to make final report on property based upon drilling? .....

Do you wish us to do the surveying of property?.....

Parties responsible for work?.....
.....

NOTE—The exploring, engineering, geology and assaying can be combined in one report, if so desired, or the drilling can be done independently of any of the other departments.

Remarks: .....
.....
.....
.....
.....

Courtesy E. J. Longyear Co.

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DIAMOND DRILLING RECORDS

THE CLEVELAND-CLIFFS IRON COMPANY,

Ishpeming, Michigan.

RECORD OF DIAMOND DRILLING.

.....Shift. .....192..

Where Working: .....

Section: ..... Hole No. .....

	Feet	Core Saved	Hours
Total depth of hole per last report.....	.....		
Moving and setting up.....	.....		.....
Drove.....inch stand pipe.....	.....		.....
Drilled with chopping bit.....	.....		.....
Drilled with diamonds.....	.....	.....	.....
Reamed from.....to.....ft.	.....		.....
Lowered.....inch casing to.....ft.	.....		.....
Total Depth of Hole.....	.....		
Kind of Material:	.....	.....	
.....	.....	.....	
.....	.....	.....	
.....	.....	.....	

	Feet	Size	Hours
Bit No.	.....	.....	.....
Bit No.	.....	.....	.....
Bit No.	.....	.....	.....
Number of Men:			

Remarks: .....

.....

.....

.....Runner.

.....Helper.

.....Setter.

.....Foreman.

Report delays, accidents, etc.

Fig. 8. Report Form for Record of Diamond-Drilling.
(Original size, 5 by 8.5 in.)

* * * * *

THE CLEVELAND CLIFFS IRON CO.

DAILY REPORT OF DIAMOND DRILLS.

Ishpeming, Mich., ...19...

Section	Hole No.	Date	Feet Drilled	Total Depth	Material	Remarks

Fig. 11. Form for Daily Report of Diamond-Drills.
(Original size, 8.5 by 11 in.)

THE CLEVELAND-CLIFFS IRON CO.

RECORD OF DIAMOND DRILLING.

District } .....
Mine } State...T...R...Sec...Hole No....Location:....

Dip:.....Course:....Drilled by whom.....with.....

Date	No. Hours	Core Recovered Ft.	Core Recovered In.	Stand Pipe	Drilled	Total Depth	Kind of Material	Begins at	Dip of Strata	Remarks

Fig. 12. Loose-Leaf Page for Records of Diamond-Drilling.
(Original size, 14 by 16 in.)

* * * * *

THE CLEVELAND-CLIFFS IRON CO.

ANALYSIS OF CUTTINGS AND CORE.

District } .....
Mine } .....
Option } State...T...R ..Sec...Hole No...Location :....
Lease } .....
Determined by ...192. Elevation of Collar.....

From	To	Iron	Phos.											

Fig. 13. Loose-Leaf Page for Record of Analysis.
(Original size, 14 by 16 in.)

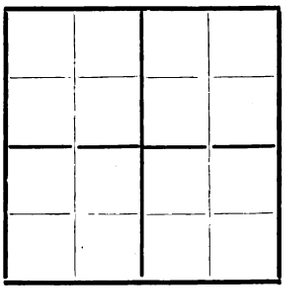
* * * * *

THE CLEVELAND-CLIFFS IRON CO.

.....Exploration.

Section..... Township..... North Range..... West.....

□ Test Pits.
O Stand Pipes.
⊕ Diamond Drill Holes.
⊕ Diamond Drill Holes showing Lean Ore. 45-50%.
⊖ Diamond Drill Holes showing second class Ore. 50-57%.
● Diamond Drill Holes showing Ore. Above 57%.



Remarks .....

.....

.....

.....

Fig. 14.—Loose-Leaf Tracing-Cloth Form for Plan of Explorations.
(Original size, 14 by 16 in.)

E. E. White, Trans. A. I. M. E., Vol. 44.

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DIAMOND DRILLING RECORDS—Continued

THE CLEVELAND-CLIFFS IRON CO.

.....Exploration Diamond Drill Holes

Section..... Township..... North Range..... West.....

Scale 1"=50'.

Fig. 15.—Loose-Leaf Tracing-Cloth Form for Sections of Drill-Holes.
(Original size, 14 by 16 in.)

* * * * *

Trans. A. I. M. E., Vol. 44.

DAILY REPORT OF DIAMOND DRILL

Location .....

Prospect No. ....19...

Depth from Breast beginning of Shift.....Feet
Depth from Breast end of Shift.....Feet

Distance Drilled .....Feet

Distance Reamed .....Feet
.....inch standpipe put in.....Feet
.....inch casing put in.....Feet

From	To	Feet	Material

Remarks: .....
.....
.....Foreman.
.....Mine.

Report cause of delays, accidents, etc.

Form used at Butte for Underground Holes. (E. & M. J.)

* * * * *

DAILY REPORT OF DIAMOND DRILL

Location..... Level..... Mine.....

Prospect No. ....19...

Depth from Breast beginning of Shift .....Feet	Carbons on Hand		Carbon in Bits		Carbons Received		Fragments on Hand	Loss in Drilling
Depth from Breast end of Shift .....Feet	No.	Carat	No.	Carat	No.	Carat	Carat	Carat
Distance Drilled .....Feet								
Distance Reamed .....Feet								
.....inch standpipe put in .....Feet								
.....inch casing put in .....Feet								

From	To	Feet	Material	Assays			
				Cu.	Ag.	Au.	Fe.

Remarks: .....
.....

Report cause of Delays, Accidents, Loss or Breaking of Carbons, etc.
Eng. & Mining Journal.

GIROUX CONSOLIDATED MINES COMPANY

CHURN DRILL REPORT.

Hole No. .....
Co-ordinate... Claim...
Drill No. .....
For.... Shift.... 19...

A. Chalcocite
B. Pyrite
C. Carbonates
D. Cuprite
E. Chalcopyrite
F. Native Copper

G. Iron Oxide
H. .....
1. Porphyry
2. Limestone
3. Rhyolite
4. .....

NAME	Occupation	HOURS						
		Drilling	Moving	Casing	Removing Casing	Repairs	Fishing	Other Delays
	Driller							
	Helper							

Casing..... Size..... Length..... Depth of Hole beginning Shift.....ft.....in.....; Adv.....ft.....in.....
Bit, Size of..... Depth of Hole at end of Shift.....in.....

Depth	Mineral	Rock	Sludge Color	Hardness	Size of Cut	Caving Yes No Slightly	No. Boilers 5-feet Sample	Exact Length of Sample Ft., In.	Exact Depth Ft., In.	Is Sample Reliable	Weight

REMARKS

(Give short account of condition of hole, rock, and depth and thickness of clay seams or fault gouge.)
.....
.....
.....
Depth of Water Level.....ft. Supplies Needed.....
Length over Sand Line Pulley to Platform.....ft.....in.....
.....Driller
Samples left in Tubs, No. .....Samples
Samples Sacked, No. ..... Seal No. .....

(Original Size, 8½ by 11 in.)

Peele's Mining Engineers' Handbook.

* * * * *

NEVADA CONSOLIDATED COPPER COMPANY

DRILL RECORD

Drill..... Hole.....
.....19...

Previous depth .....
Present depth .....
Feet drilled .....
Hours drilling .....
Hours lost .....
Tons coal .....
Cords wood .....
Driller hours .....
Helper hours .....
Laborers .....
Wages, $.....
Supplies .....
Cost per foot .....
Remarks .....
.....
.....Foreman
.....Driller
Av. ft. per hr.....

(Original size 3¾ by 8¼ in.)

Peele's Mining Engineers' Handbook.

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SULLIVAN MACHINERY COMPANY

129 South Michigan Ave., CHICAGO, ILL., U.S.A.

DOMESTIC SALES OFFICES
Birmingham, Boston, Butte, Claremont, N. H., Cleveland, Dallas, Denver, Duluth, El Paso, Huntington, W. Va., Joplin, Knoxville, New York, Pittsburgh, St. Louis, Salt Lake, San Francisco, Spokane, Terre Haute.

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Sullivan Products

Air Compressors; Air Lift Pumps; Diamond Drills; All-Hammer Drill Sharpeners; Drill Steel Furnaces; Forge Hammers; Ironclad Coal Cutters; Rock and Hammer Drills; Quarrying Machinery; Contractors for Diamond Core Drilling; Turbinair Portable Hoists.

Prospecting by Contract

When examining mines, oil or mineral lands, write to the Contract Drilling Department of this Company for prices and expert advice. We have been in the drilling business since 1884, and are ready to undertake prospecting at any time and anywhere, with up-to-date Sullivan Diamond Drills and the latest appliances for recovering the largest possible percentage of core.

Sullivan Diamond Drills have stood for accuracy in mineral prospecting since 1875. Built and stocked in a dozen styles, for capacities to 6,500 feet. Standard core fittings, $1\frac{5}{8}$ to 2 in. diameter. Hand, gas-engine, steam or air power. Will drill holes and take cores at any angle. Improved hydraulic or screw (friction) feed, and remodeled hoisting gear.

Diamond Drill

Ask for Bulletin 69-MMC

Sullivan Diamond Core Drill, Alaska Treadwell Mines, Douglas Island, Alaska. Used for horizontal underground holes

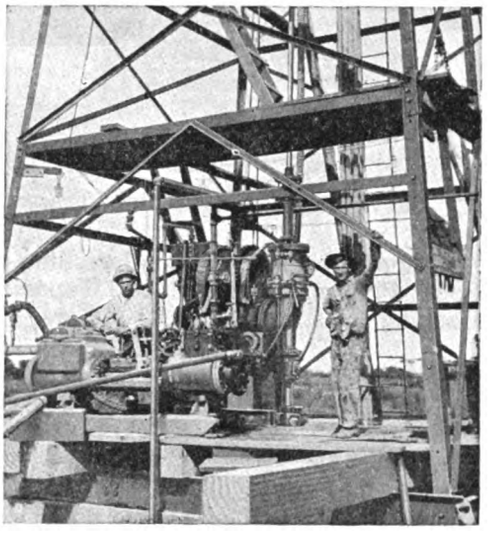
SPECIFICATIONS OF SULLIVAN DIAMOND DRILLS

Size of Drill	Depth of Hole Feet	Diameter of Hole Inches	Diameter of Core Inches	Horse-Power Required	Feed: Screw or Hydraulic ("S" or "H")	Weight Drill and Partial Equipment
Bravo (Hand)	50 to 500	$1\frac{9}{16}$	$1\frac{1}{8}$	Hand	S	1085
Bravo (Belt)	50 to 600	$1\frac{9}{16}$	$1\frac{1}{8}$	4 H. P.	S	1485*
E	50 to 500	$1\frac{9}{16}$	$1\frac{1}{8}$	8	S	1408
Beauty	100 to 1000	$1\frac{9}{16}$	$1\frac{1}{8}$	8	S	1715
H	200 to 1600	$1\frac{13}{16}$	$1\frac{1}{16}$	15	H	3443
HG	200 to 1600	$1\frac{13}{16}$	$1\frac{1}{16}$	15	H	3443
H (Belt)	200 to 1600	$1\frac{13}{16}$	$1\frac{1}{16}$	15	H	3671
C	500 to 2200	$1\frac{13}{16}$	$1\frac{1}{16}$	15	H	3947
B	1500 to 3200	$2\frac{1}{16}$	$1\frac{5}{16}$	15	H	5538
HN	100 to 900	$2\frac{1}{16}$	2	15	H	3955
CN	200 to 1200	$2\frac{1}{16}$	2	15	H	4329
N	1200 to 2500	$2\frac{1}{16}$	2	20	H	5730
P	3500 to 5500	$2\frac{1}{16}$	2	25	H	10924
†P-2	2000 to 3000	$3\frac{7}{16}$	$2\frac{3}{4}$	45	H	11500

*Does not include gasoline engine. †For oil drilling.

Sullivan Reliability

The importance of employing a drilling firm of absolute reliability and of the highest possible standing cannot be over-estimated. The accuracy of the process, the efficiency of the tools used, the skill of the operators, and the responsibility of the contractor behind the drills and men should be considered most carefully. Engineers, mine owners and mineral land purchasers everywhere accept core records, if secured by this company, as conclusive evidence of the thickness, depth, and purity of the veins penetrated.



Diamond Drills for Oil Wild-catting and Production Drilling Are Also Available

We do from 40 to 50 miles of contract drilling annually. Shall we send one of our field experts to learn your requirements and quote you a price per foot? Booklet 122-MC contains further details.

Specimen List of Equipment for "H," "HG" or "C" Diamond Drills

For Prospecting from the Surface (Size of Core Fittings 1⅝ inch)

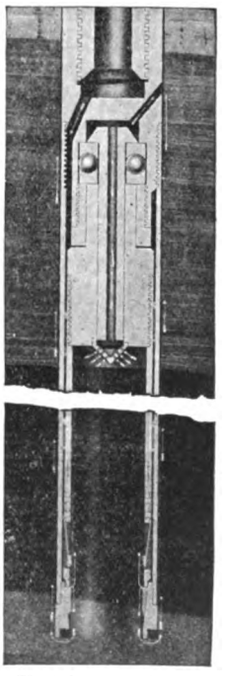
Partial Equipment, included in the Price of the Drill

1 5-foot "A" drill rod with coupling.
1 10-foot core barrel.
1 safety clamp.
1 sheave with strap and hook for hoisting rods.
1 tool chest with lock and key.
1 bail and bolt for hanging sheave.
1 lifting bail with clevis.
1 hoisting swivel with coupling
1 water swivel coupling and elbow.
1 lot rubber and hemp packing and waste.
1 machinist's hammer
1 screw driver
1 draw bolt for gear
1 6-inch adjustable level
2 pipe tongs
1 1-gallon oil can.
1 hand oil can
1 2-inch lubricator with valve.
All pipe and fittings necessary to connect drill, pump and boiler.
3 swivel unions for steam piping
1 complete set of diamond setting tools, consisting of:—
1 3½-inch jaw vise, with swivel base.
1 breast drill, with 5 bits from ½-inch to ½-inch diameter.
1 set of 12 setting chisels and punches.
1 pair each, 6-inch dividers, inside and outside calipers.
1 setting block.
1 hammer for diamond setting.
1 pipe wrench.
1 monkey wrench.
1 complete set of solid wrenches for engine, chuck, etc.
25 feet 1-inch, 5-ply water hose with connections for drill rods.
12 feet 1-inch, 5-ply water hose with connections to drill and pump
5 feet ½-inch, 4-ply drip hose
1 packing mould is included for export

Additional Operating Equipment (Prices upon application)

1 1 15-H.P standard boiler on wheels with injector and complete fittings.
2. 1 special pump (duplex), size 6x12x6
3. 16 feet 3½-inch suction hose, with connections, and strainer with union
4. 800-foot "A" drill rods with couplings, 10-foot lengths
5. 24 blank bits.
6. 4 split ring core lifters.
7. 2 bevel core shells.
8. 1 cross chopping bit.
9. 50-feet 3-inch drive pipe or (stand pipe)
10. 1 steel drive head for 3-inch pipe
11. 1 steel drive shoe for 3-inch pipe
12. 1 drive pipe chopping bit, for size 3-inch drive pipe.
13. 1 drive pipe clamp, for size 3-inch drive pipe
14. 1 570-pound cast iron drive block
15. 100-feet 2-inch right hand casing pipe, flush joint style (in 10-foot lengths)
16 10 pairs protectors for above casing
17 1 casing clamp for 2-inch casing
18 1 bushing "A" rods to 2-inch casing
19 1 improved 10-foot reamer for 2-inch casing
20 1 extra reamer face
21 1 pipe cutter cutting pipe to 2 inches
22 1 set pipe stocks and dies threading pipe ½ inch to 2 inches in diameter
23 2 jack screws
24. 1 each 7-inch single and double blocks with 100 feet of ½-inch manila rope.
25 15 feet of ½ inch chain with hook and ring
26 1 flue cleaner, poker and ash hoe, with boiler only
27 1 shovel, 2 crowbars, handsaw, files and cold chisels.
28 1 sledge, pick, auger and 2 axes with handles
29 1 lot of small pipe, valves and fittings, extra waste and packing.
30 1 set carbon, 8 stones, weight 12 karats

Add necessary rods for greater depths. More or less stand pipe or casing may be used, depending on conditions.



Sketch to Show Sullivan Improved Double-Tube Core Barrel taking Core from a coal seam.

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BUFF & BUFF MANUFACTURING CO.

Jamaica Plain Station, Boston, Mass.

Specialists on Surveying Instruments

Products

"Buff" Surveying Instruments; Transits and Levels.

Also, Theodolites; Tripods; Levelling Rods; Plumb-Bobs; Plummet Lamps; Steel Tapes; Range Poles; Marking Pins, and Current Meters.

Permanent Accuracy

—the one thing the Engineer **must** have, is insured by the Buff experience of **sixty years** of successful Instrument-Making.

The Chief Engineer of a great Canadian Railway System writes us: "There is no doubt but you produce the best instrument made on the American continent."

Please investigate the Buff before you purchase!

Directions for Ordering

Order (especially triangulation transits) as long beforehand as possible, to insure careful construction if not in stock. State plainly style, size, kind of finish, price, shipping directions, name of express company, etc.

Repairs to Instruments

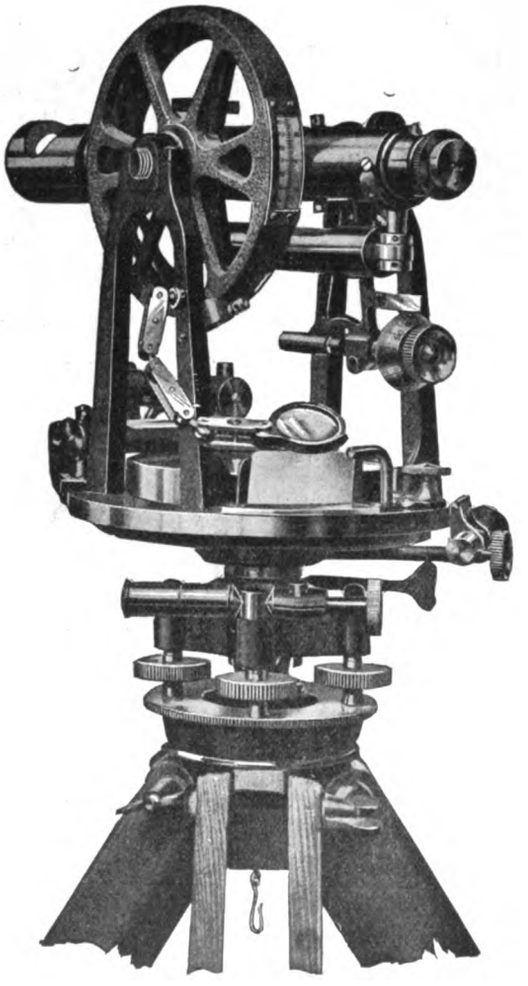
"Buff" Transits, solidly built to resist blows and falls, have metal generously distributed thruout the construction. At the Jamaica Plain Shops, all makes are put in good order and adjustment.

Injured parts of instruments are duplicated from stock in hand. Parts to be repaired should be pointed out in detail. When so ordered, all instruments are put into "thoro order and adjustment" at lowest expense.

References

This company are Instrument Makers to the United States Government, many departments; N. Y. C. R. R.; N. Y., N. H. & H. R. R.; New York Water Board; Public Service Commission, New York City; Board of Public Works, New York City; Standard Oil Co., Guggenheim and Rothschild interests, J. G. White Co., and numerous other engineering organizations.

The Pennsylvania R. R. used "Buff" instruments in large numbers in both their North River and East River Tunnels. The Subway Commission of New York are now using 250 "Buff" instruments.



The Buff Precise Mine Transit No. 3G

The strongest, most accurate line of Mining Instruments. All types and sizes. All the latest improvements.

Send for Catalog No. 95, to Boston, Mass.

Use a Buff for Accuracy.

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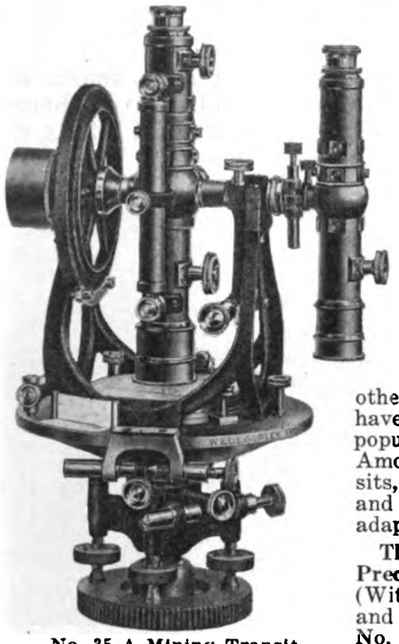
TROY, NEW YORK

Engineering Instruments

Products

Engineering Instruments. Transits; Wye Levels; Compasses; Alidades; Plane Tables; Water Level Registers; Steel Tapes, etc.

The name Gurley has, for more than three quarters of a century, been the identifying mark of Engineering Instruments, built in accordance with our unvarying standard —the highest accuracy and precision attainable by human care and ingenuity.



No. 35-A Mining Transit

This standard, set by Gurley Instruments, has been acknowledged by the Engineering Profession in all parts of the world.

Transits

We have selected, for this page, only those transits and other instruments which have proven especially popular in the mining field. Among the Gurley Transits, the Nos. 27-A, 28 and 20-A are particularly adapted to mining work.

The Gurley No. 27-A Precise Mining Transit. (With Interchangeable Top and Side Telescope, No. 35-A). For mine and other difficult surveying the Gurley Precise Mining Transit, equipped with the Interchangeable Top and Side Telescope, for use in vertical sighting, will be found to possess features of unusual merit. The general construction is that of the well known line of Gurley Precise Mountain Transit, with patented One-Piece Truss Standard, radially ribbed and dished limb and top plate, and flush vernier glasses, with waterproof seal. The waterproof feature has also been incorporated in the needle base, making this instrument impervious to moisture.

The Gurley Diagonal Prism will frequently be found useful in stoping developments.

The Gurley No. 28 Light Mountain Transit is frequently demanded by those who prefer a larger compass. It has a 4″ needle in place of the 3″ needle of the No. 27-A. It can also be equipped with the Interchangeable Side and Top Telescope and with the Diagonal Prism.

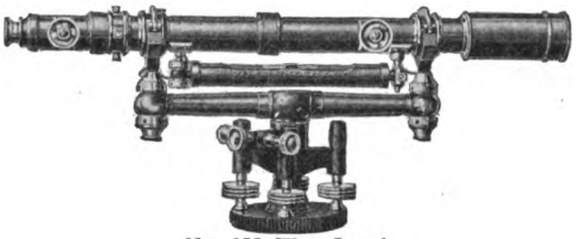
The Gurley No. 20-A Explorers Precise Transit is the smallest and lightest Gurley Transit built.

No. 20-A Explorers Transit

MINING TRANSIT SPECIFICATIONS

Transit No.	27-A	28	20-A
Limb	5.65″	5.65″	4″
Needle	3.5 ″	4″	2.13″
Telescope	11″	8″	6.5 ″
Vertical Limb	Full Circle	Arc	Full Circle
Vertical Limb Diameter	4.5″	5″	4″
Weight	16.5 lbs.	11.5 lbs.	5 lbs.

It is designed especially for work in which the utmost convenience in carrying and handling is wanted. It is fully equal in quality to the larger Gurley Transits in every respect, and can be depended upon for accuracy in design and workmanship.



No. 377 Wye Level

Wye Levels

From the time the first Gurley Level was made, more than three quarters of a century ago, Gurley Levels have earned the preference of keen engineers, and progressive refinements have earnd for them a reputation which is world-wide.

The instrument which we recommend and which most engineers choose for all around work is the Gurley No. 377. The No. 375 and No. 378 Levels are marked by the same accuracy, durability and superior workmanship, with every provision for constant operation and adjustment, the only difference lying in the size.

The Gurley Explorers Level, No. 384, is, like the Explorers Transit, designed with the object of extreme compactness and light weight.

WYE LEVEL SPECIFICATIONS

Level No.	375	377	378	384
Telescope	22″	18″	15″	6.5″
Power	42 diam.	32 diam.	26 diam.	16 diam.
Telescope Level	10¼″	8.38″	8.38″	3″
Weight	14½ lbs.	13¼ lbs.	11½ lbs.	2¾ lbs.

Gurley Mining Rod

This is the same general construction as our regular full length Philadelphia Rod, which has found such unusual favor. It is built especially to meet the requirements of the mining engineer, being only 3 3/10 feet long when closed. Two-ply construction, sliding to 5 feet, graduated in feet, 10ths and 100ths, with vernier reading to 1,000ths. May be used with or without target.

No. 500-B

Gurley Dip Compass

This is a carefully built compass with a 3 inch needle, suspended to operate when held either horizontally or vertically. It may be used as an ordinary compass when held horizontally, and, by holding vertically, it will indicate the presence of magnetic ore bodies.

No. 341-A

Steel Tapes

To round out the engineers equipment, the company offers the better grade of steel tapes, with or without Bureau of Standard Certificates.

We will be glad to send complete Gurley catalog to all those interested in the full line of Gurley Instruments.

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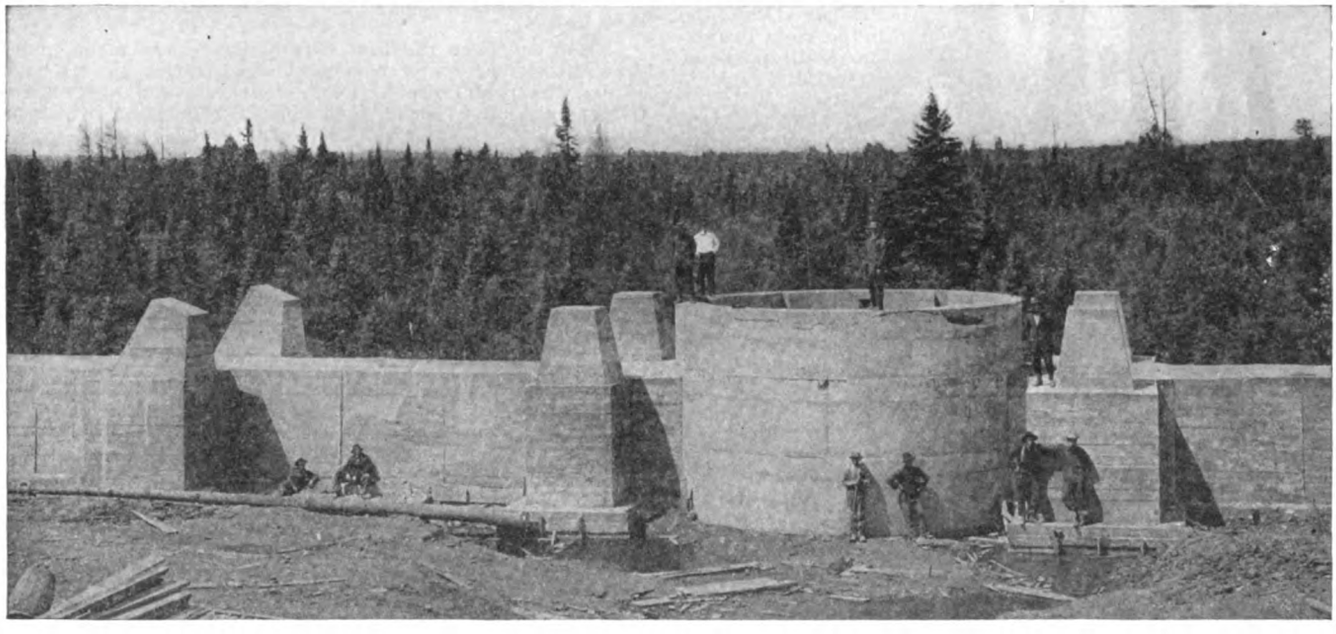
LONDON, ENGLAND
PARIS, FRANCE
LIMA, PERU
HAVANA, CUBA
MEXICO CITY, MEXICO

Engineers and Mining Contractors

Service

The Foundation Company is widely experienced in the design and construction of mine shafts and tunnels. It specializes in the pneumatic caisson method, which insures successful results in treacherous ground. It also builds railroads, bridges, steam and hydro-electric power plants, industrial plants and other types of heavy engineering construction.



The Northlake Iron Mine Shaft for the Cleveland Cliffs Iron Company, Ishpeming, Mich., 24 Feet in Diameter Through 77 Feet of Quicksand

THE FOLLOWING MINING COMPANIES HAVE ENTRUSTED TO THE FOUNDATION COMPANY THE SINKING OF SHAFTS SOME OF WHICH ARE AS LARGE AS 38 FEET IN DIAMETER AND OTHERS AS DEEP AS 1000 FEET

American Salt & Coal Company.
Ammo. Phos. Corporation.
Bangor Mining Company.
Calumet-Hecla Mining Company.
Carey Salt Company.
Cleveland Cliffs Iron Company.
Crown Gypsum Company.
Cuyler Adams Company.
D. L. & W. Railway Company.
Dominion Coal Company.
Fort Henry Mining Company.
Inland Steel Company.
Iroquois Iron Company.
Island Creek Coal Company.
Miami Copper Company.
Munro Iron Mining Company.
North American Mining Company.
Norwood-White Coal Company.
Oliver Iron Mining Company.
Pickands Mather Company.
Penelec Coal Company.
Ramapo Ore Company.
Ray Consolidated Copper Company.
Rogers-Brown Mining Company.
Syracuse Mining Company.
Scranton Mining Company.
St. Albert Collieries Company.
Tod-Stambaugh.
U. S. War Department.
Vesta Coal Company.
Wickwire Mining Company.

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ROBERT W. HUNT & CO.

ENGINEERS

CHICAGO, ILL. 175 W. Jackson Blvd.	NEW YORK CITY 53 Park Place	ST. LOUIS, MO. Syndicate Trust Bldg.	PITTSBURGH, PA. Monongahela Bank Bldg.	LONDON, ENG. 52 Queen Victoria St., E. C. 4
KANSAS CITY, MO. Orear-Leslie Bldg.	CINCINNATI, OHIO 509 Gerke Bldg.	NEW ORLEANS, LA. 919 Carondelet Bldg.	SEATTLE, WASH. 410 Lyons Bldg.	DALLAS, TEXAS Great Southern Life Bldg.
PHILADELHPHIA, PA. 26 S. 15th St.	MONTREAL, CAN. 905 McGill Bldg.	VANCOUVER, CAN. Standard Bank Bldg.	TORONTO, CAN. Bank of Hamilton Bldg.	SAN FRANCISCO, CAL. 251 Kearny Street
MEXICO CITY, MEX.	PICHER, OKLA.	GADSDEN, ALA.	BANNER, KY.	BEARDSTOWN, ILL.

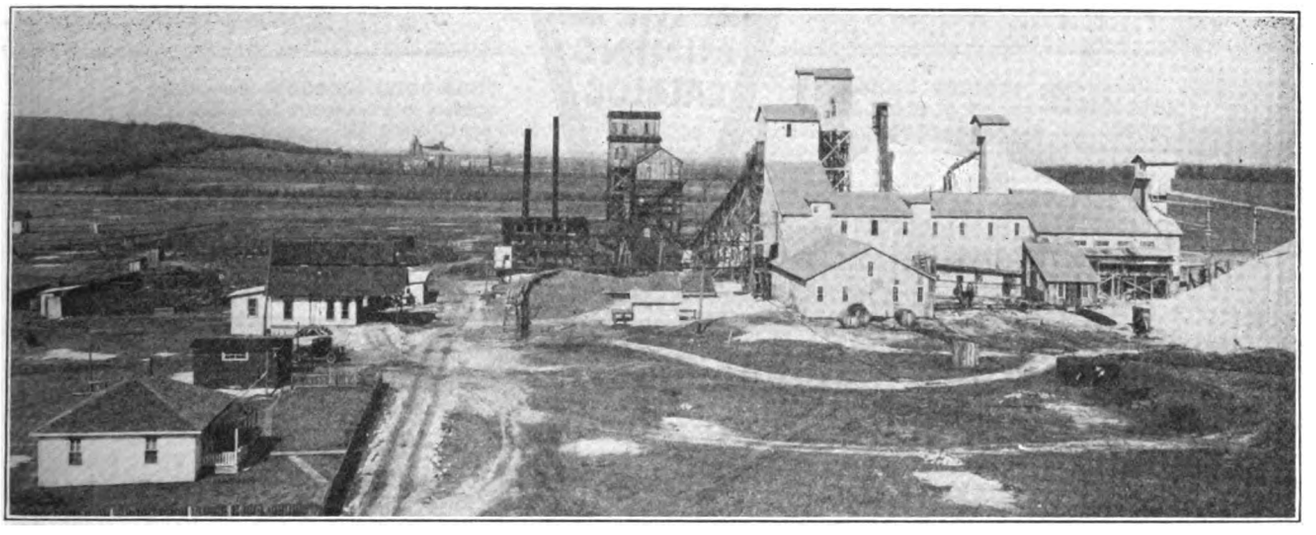
IN ADDITION TO THIRTY-SIX (36) OTHER LOCATIONS OF RESIDENT INSPECTORS AND REPRESENTATIVES WHO ARE PARTICULARLY QUALIFIED TO HANDLE RAW MATERIALS AND MANUFACTURED PRODUCTS

To the Operator

We make Reports, Appraisals and Valuations of properties; Analyses of coal and minerals; Tests of machinery; Design and Superintend construction of buildings, tipples and special machinery; Inspect and Report upon materials and appliances offered for sale and trace shipments and deliveries to you.

To the Manufacturer

We analyze, test and inspect raw and finished materials of all kinds, and are in a position to run practical operating tests of and report upon any kind of mining machinery or appliances for use in Coal and Metal Mines, from experiments made at properties operated as subsidiaries.



Modern 800-Ton Lead and Zinc Mine, Designed and Constructed by our Company in the Miami Oklahoma Field

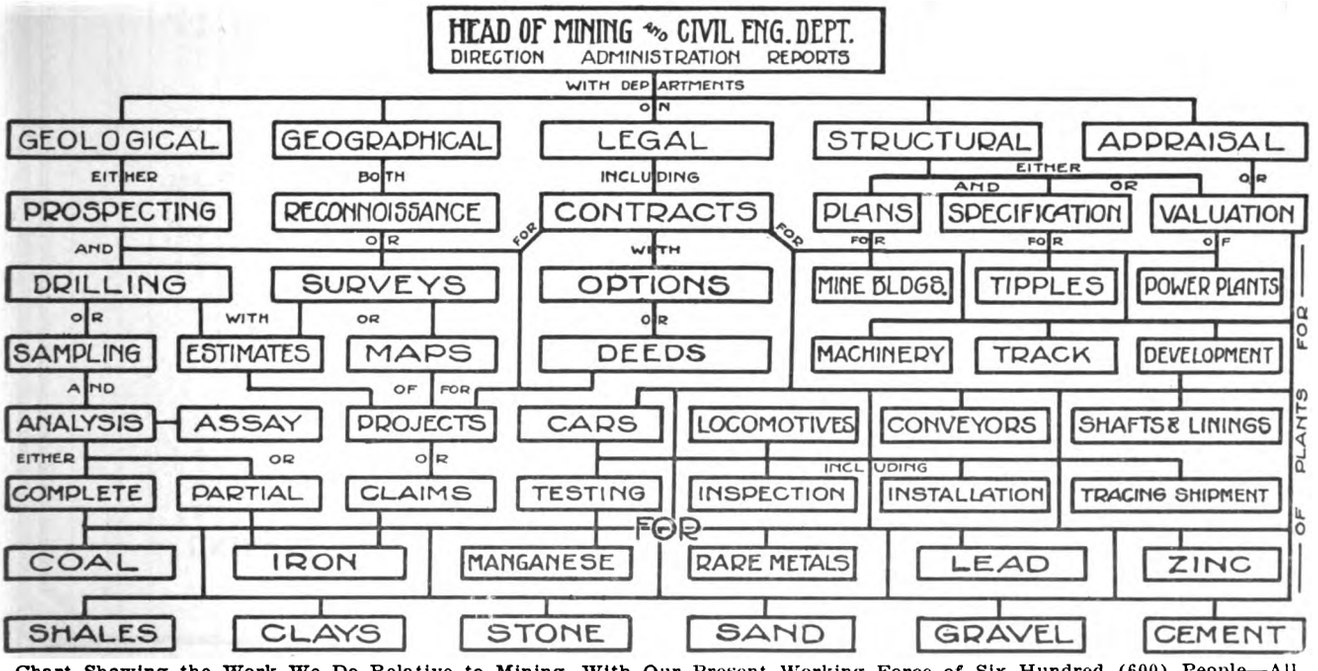


Chart Showing the Work We Do Relative to Mining, With Our Present Working Force of Six Hundred (600) People—All Experts in Their Particular Line

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SECTION II

Building Materials, Mine Timbering and Supports

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

American Zinc Products Co., The
Asbestos Shingle, Slate & Sheathing Co.
Cabot, Samuel, Inc.
Ryerson, Joseph T. & Son
Wisconsin Bridge & Iron Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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Safe Load Tables---Wooden Beams

The safe load table of wooden beams which follows is based upon the working unit stresses adopted by the American Railway Engineering Association, and gives the uniformly distributed safe loads for rectangular sections one inch thick. The safe load for a beam of any thickness is then found by multiplying the tabular value by the thickness of the beam in inches. The safe loads include the weight of the beams and are computed on the assumption that the beams are braced against lateral deflection.

RECTANGULAR WOODEN BEAMS—ONE INCH THICK

Maximum Safe Loads and Limiting Spans

Depth of Beam, Inches	White Oak		Longleaf Pine		Shortleaf Pine		White Pine		Douglas Fir		Western Hemlock		Spruce	
	Max. Load, Lbs.	Min. Span, Ft.	Max. Load, Lbs.	Min. Span, Ft.	Max. Load, Lbs.	Min. Span, Ft.	Max. Load, Lbs.	Min. Span, Ft.	Max. Load, Lbs.	Min. Span, Ft.	Max. Load, Lbs.	Min. Span, Ft.	Max. Load, Lbs.	Min. Span, Ft.
2	293	1.7	320	1.8	347	1.5	187	2.1	293	1.8	267	1.8	187	2.4
4	587	3.3	640	3.6	693	3.1	373	4.3	587	3.6	533	3.7	373	4.8
6	880	5.0	960	5.4	1040	4.6	560	6.4	880	5.5	800	5.5	560	7.1
8	1173	6.7	1280	7.2	1387	6.2	747	8.6	1173	7.3	1067	7.3	747	9.5
10	1467	8.3	1600	9.0	1733	7.7	933	10.7	1467	9.1	1333	9.2	933	11.9
12	1760	10.0	1920	10.8	2080	9.2	1120	12.9	1760	10.9	1600	11.0	1120	14.3
14	2053	11.7	2240	12.6	2427	10.8	1307	15.0	2053	12.7	1867	12.8	1307	16.7
16	2347	13.3	2560	14.4	2773	12.3	1493	17.1	2347	14.5	2133	14.7	1493	19.0
18	2640	15.0	2880	16.3	3120	13.8	1680	19.3	2640	16.4	2400	16.5	1680	21.4
20	2933	16.7	3200	18.1	3467	15.4	1867	21.4	2933	18.2	2667	18.3	1867	23.8
22	3227	18.3	3520	19.9	3813	16.9	2053	23.6	3227	20.0	2933	20.2	2053	26.2
24	3520	20.0	3840	21.7	4160	18.5	2240	25.7	3520	21.8	3200	22.0	2240	28.6

SQUARE WOODEN COLUMNS

Safe Loads in Thousands of Pounds

American Railway Engineering Association Formulas

	Length Feet	Side of Square, Inches						
		4	6	8	10	12	14	16
LONGLEAF PINE, WHITE OAK 1300 (1—1/60d)	5	15.6						
	6	15.6						
	7	14.6						
	8	13.5	35.1					
	9	12.5	34.3	62.4				
	10	11.4	32.8	62.4				
	11	10.4	31.2	60.3				
	12		29.6	58.2	97.5			
	14		28.1	54.1	93.6	140.4		
	16		25.0	49.9	88.4	137.3	191.1	
	18			45.8	83.2	131.0	189.3	249.6
	20			41.6	78.0	124.8	182.0	249.6
DOUGLAS FIR WESTERN HEMLOCK 1200 (1—1/60d)	5	14.4						
	6	14.4						
	7	13.4						
	8	12.5	32.4					
	9	11.5	31.7	57.6				
	10	10.6	30.2	57.6				
	11	9.6	28.8	55.7				
	12		27.4	53.8	90.0			
	14		25.9	49.9	86.4	129.6		
	16		23.0	46.1	81.6	126.7	176.4	
	18			42.2	76.8	121.0	174.7	230.4
	20			38.4	72.0	115.2	168.0	230.4
SHORTLEAF PINE, SPRUCE 1100 (1—1/60d)	5	13.2						
	6	13.2						
	7	12.3						
	8	11.4	29.7					
	9	10.6	29.0	52.8				
	10	9.7	27.7	52.8				
	11	8.8	26.4	51.0				
	12		25.1	49.3	82.5			
	14		23.8	45.8	79.2	118.8		
	16		21.1	42.2	74.8	116.2	161.7	
	18			38.7	70.4	110.9	160.2	211.2
	20			35.2	66.0	105.6	154.0	211.2
WHITE PINE, TAMARACK 1000 (1—1/60d)	5	12.0						
	6	12.0						
	7	11.2						
	8	10.4	27.0					
	9	9.6	26.4	48.0				
	10	8.8	25.2	48.0				
	11	8.0	24.0	46.4				
	12		22.8	44.8	75.0			
	14		21.6	41.6	72.0	108.0		
	16		19.2	38.4	68.0	105.6	147.0	
	18			35.2	64.0	100.8	145.6	192.0
	20			32.0	60.0	96.0	140.0	192.0

Loads above horizontal lines are the maxium allowable safe loads.

ROUND WOODEN COLUMNS

Safe Loads in Thousands of Pounds

American Railway Engineering Association Formulas

	Length Feet	Diameter, Inches						
		4	6	8	10	12	14	16
LONGLEAF PINE, WHITE OAK 1300 (1—1/60d)	5	12.3						
	6	12.3						
	7	11.4						
	8	10.6	27.6					
	9	9.8	27.0	49.0				
	10	9.0	25.7	49.0				
	11	8.2	24.5	47.4				
	12		23.3	45.7	76.6			
	14		22.1	42.5	73.5	110.8		
	16		19.6	39.2	69.4	107.8	150.1	
	18			35.9	65.3	102.9	148.7	196.0
	20			32.7	61.3	98.0	142.9	196.0
DOUGLAS FIR WESTERN HEMLOCK 1200 (1—1/60d)	5	11.3						
	6	11.3						
	7	10.6						
	8	9.8	25.4					
	9	9.1	24.9					
	10	8.3	23.7	45.2				
	11	7.5	22.6	45.2				
	12		21.5	43.7	70.7			
	14		20.4	42.2	67.9	101.8		
	16		18.1	39.2	64.1	99.5	138.5	
	18			33.2	60.3	95.0	137.2	181.0
	20			30.2	56.5	90.5	132.0	181.0
SHORTLEAF PINE, SPRUCE 1100 (1—1/60d)	5	10.4						
	6	10.4						
	7	9.7						
	8	9.0	23.3					
	9	8.3	22.8	41.5				
	10	7.6	21.8	41.5				
	11	6.9	20.7	40.1				
	12		19.7	38.7	64.8			
	14		18.7	35.9	62.2	93.3		
	16		16.6	33.2	58.7	91.2	127.0	
	18			30.4	55.3	87.1	125.8	165.9
	20			27.6	51.8	82.9	121.0	165.9
WHITE PINE, TAMARACK 1000 (1—1/60d)	5	9.4						
	6	9.4						
	7	8.8						
	8	8.2	21.2					
	9	7.5	20.7	37.7				
	10	6.9	19.8	37.7				
	11	6.3	18.9	36.4				
	12		17.9	35.2	58.9			
	14		17.0	32.7	56.5	84.8		
	16		15.1	30.2	53.4	82.9	115.5	
	18			27.6	50.3	79.2	114.4	150.8
	20			25.1	47.1	75.4	110.0	150.8

Loads above horizontal lines are the maxium allowable safe loads.

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SAFE LOAD TABLES—STEEL BEAMS

Depth, Inches	Pounds per Foot	Span in Feet																			
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
27	83	22820	18860	15850	13500	11640	10140	8920	7900	7040	6320	5710	5180	4720	4310	3960	3650	3380	3130	2910	2540
	115	26270	21710	18240	15550	13400	11680	10260	9090	8110	7280	6570	5960	5430	4970	4560	4200	3890	3600	3350	2920
	110	25630	21180	17800	15170	13080	11390	10010	8870	7910	7100	6410	5810	5300	4850	4450	4100	3790	3520	3270	2850
	105	24990	20650	17360	14790	12750	11110	9760	8650	7710	6920	6250	5670	5160	4720	4340	4000	3700	3430	3190	2780
	100	21150	17480	14690	12520	10790	9400	8260	7320	6530	5860	5290	4800	4370	4000	3670	3380	3130	2000	2700	2350
24	95	20520	16960	14250	12150	10470	9120	8020	7100	6340	5690	5130	4650	4240	3880	3560	3280	3040	2820	2620	2280
	90	19900	16440	13820	11770	10150	8840	7770	6880	6140	5510	4970	4510	4110	3760	3450	3180	2940	2730	2540	2210
	85	19270	15930	13380	11400	9830	8560	7530	6670	5950	5340	4820	4370	3980	3640	3350	3080	2850	2640	2460	2140
	80	18550	15330	12880	10980	9470	8250	7250	6420	5730	5140	4640	4210	3830	3510	3220	2970	2750	2550	2370	2060
	69.5	17140	14160	11900	10140	8740	7620	6690	5330	5290	4750	4280	3890	3540	3240	2980	2740	2540	2350	2190	1900
21	57.5	12470	10310	8660	7380	6360	5540	4870	4320	3850	3450	3120	2830	2580	2360	2170	2000	1850	1710	1590	1390
	100	17660	14590	12260	10450	9010	7850	6900	6110	5450	4890	4420	4000	3650	3340	3070	2830	2610	2420	2250	1960
	95	17140	14160	11900	10140	8740	7620	6690	5930	5290	4750	4280	3890	3540	3240	2980	2740	2540	2350	2190	1900
	90	16610	13730	11540	9830	8480	7380	6490	5750	5130	4600	4150	3770	3430	3140	2880	2660	2460	2280	2120	1850
	85	16090	13300	11170	9520	8210	7150	6290	5570	4970	4460	4020	3650	3320	3040	2790	2570	2380	2210	2050	1790
20	80	15640	12930	10860	9260	7980	6950	6110	5410	4830	4330	3910	3550	3230	2960	2720	2500	2310	2150	2000	1740
	75	13530	11180	9400	8010	6910	6020	5290	4680	4180	3750	3380	3070	2800	2560	2350	2170	2000	1860	1730	1500
	70	13010	10750	9040	7700	6640	5780	5080	4500	4020	3600	3250	2950	2690	2460	2260	2080	1920	1790	1660	1450
	65	12480	10310	8660	7380	6370	5440	4870	4320	3850	3460	3120	2830	2580	2360	2170	2000	1850	1710	1590	1390
	90	14940	12350	10370	8840	7620	6640	5840	5170	4610	4130	3730	3390	3090	2820	2590	2390	2210	2050	1910	1660
	85	14470	11960	10050	8560	7380	6430	5650	5010	4470	4010	3620	3280	2990	2740	2510	2310	2140	1980	1850	1610
	80	14000	11570	9720	8280	7140	6220	5470	4840	4320	3880	3500	3170	2890	2650	2430	2240	2070	1920	1790	1560
	75	13530	11180	9390	8000	6900	6010	5280	4680	4180	3750	3380	3070	2800	2560	2350	2160	2000	1860	1730	1500
18	70	10920	9020	7580	6460	5570	4850	4260	3780	3370	3020	2730	2480	2260	2060	1900	1750	1620	1500	1390	1210
	65	10450	8630	7260	6180	5330	4640	4080	3620	3220	2890	2610	2370	2160	1970	1810	1670	1550	1430	1330	1160
	60	9980	8250	6930	5900	5090	4430	3900	3450	3080	2760	2490	2260	2060	1890	1730	1600	1480	1370	1270	1110
	55	9430	7790	6550	5580	4810	4190	3680	3260	2910	2610	2330	2140	1950	1780	1640	1510	1400	1290	1200	1050
	46	8690	7180	6040	5140	4430	3860	3390	3010	2680	2410	2170	1970	1800	1640	1510	1390	1290	1190	1110	970

Depth, Inches	Pounds per Foot	Span in Feet																				
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	75	27310	20060	15360	12140	9830	8120	6830	5820	5020	4370	3840	3400	3030	2720	2460	2230	2030	1860	1710	1570	1450
	70	26220	19260	14750	11650	9440	7800	6550	5590	4820	4200	3690	3270	2910	2610	2360	2140	1950	1780	1640	1510	1400
	65	25130	18460	14140	11170	9050	7480	6280	5350	4620	4020	3530	3130	2790	2510	2260	2050	1870	1710	1570	1450	1340
	60	24060	17680	13530	10690	8660	7160	6010	5130	4420	3850	3380	3000	2670	2400	2170	1960	1790	1640	1500	1390	1280
15	55	20190	14830	11360	8970	7270	6010	5050	4300	3710	3230	2840	2520	2240	2010	1820	1650	1500	1370	1260	1160	1080
	50	19100	14030	10740	8490	6880	5680	4780	4070	3510	3060	2690	2380	2120	1910	1720	1560	1420	1300	1190	1100	1020
	45	18010	13230	10130	8000	6480	5360	4500	3840	3310	2880	2530	2240	2000	1800	1620	1470	1340	1230	1130	1040	960
	42	17450	12820	9820	7760	6280	5190	4360	3720	3210	2790	2450	2170	1940	1740	1570	1430	1300	1190	1090	1010	930
	37.5	16020	11770	9010	7120	5770	4770	4010	3410	2940	2560	2250	2000	1780	1600	1440	1310	1190	1090	1000	920	850
	55	15850	11650	8920	7050	5710	4720	3960	3380	2910	2540	2230	1980	1760	1580	1430	1290	1180	1080	990	910	840
	50	14980	11010	8430	6660	5390	4460	3750	3190	2750	2400	2110	1870	1660	1490	1350	1220	1110	1020	940	860	800
	45	14110	10370	7940	6270	5080	4200	3530	3010	2590	2260	1980	1760	1570	1410	1270	1150	1050	960	880	810	750
12	40	13280	9760	7470	5900	4780	3950	3320	2830	2440	2130	1870	1650	1480	1320	1200	1080	990	900	830	770	710
	35	11270	8280	6340	5010	4060	3350	2820	2400	2070	1800	1580	1400	1250	1120	1020	920	840	770	700	650	600
	31.5	10660	7830	6000	4740	3840	3170	2660	2270	1960	1710	1500	1330	1180	1060	960	870	790	730	670	610	570
	28	9850	7240	5540	4380	3550	2930	2460	2100	1810	1580	1390	1230	1090	980	890	800	730	670	620	570	520
	40	9400	6910	5290	4180	3390	2800	2350	2000	1730	1500	1320	1170	1040	940	850	770	700				
	35	8680	6380	4880	3860	3120	2580	2170	1850	1590	1390	1220	1080	960	870	780	710	650				
10	30	7950	5840	4470	3530	2860	2370	1990	1690	1460	1270	1120	990	880	790	720	650	590				
	25	7240	5320	4070	3220	2610	2150	1810	1540	1330	1160	1020	900	800	720	650	590	540				
	22.25	6730	4950	3790	2990	2420	2000	1680	1430	1240	1080	950	840	750	670	610	550	500				
	35	7360	5410	4140	3270	2650	2190	1840	1570	1350	1180	1040	920	820	730	660						
9	30	6710	4930	3770	2980	2420	2000	1680	1430	1230	1070	940	840	750	670	600						
	25	6050	4450	3410	2690	2180	1800	1510	1290	1110	970	850	750	670	600	540						
	21	5590	4110	3150	2490	2010	1660	1400	1190	1030	900	790	700	620	560	500						

Loads within heavy horizontal lines are maximum loads for web shear.
Loads below dotted horizontal lines will produce excessive deflection.

Depth, Inches	Pounds per Foot	Span in Feet																				
		2	2½	3	3½	4	4½	5	5½	6	6½	7	8	9	10	11	12	13	14	15	16	17	18
	25.5	43280	29200	20280	14900	11410	9010	7300	6030	5070	4320	3720	2850	2250	1830	1510	1270	1080	930	810	710	630	560
	23.	35920	27520	19110	14040	10750	8490	6880	5690	4780	4070	3510	2690	2120	1720	1420	1190	1020	880	760	670	600	530
8	20.5	28560	22840	17950	13190	10100	7980	6460	5340	4490	3820	3300	2520	1990	1620	1340	1120	960	820	720	630	560	500
	18.	21600	17280	14400	12340	9480	7490	6070	5010	4210	3590	3100	2370	1870	1520	1250	1050	900	770	670	590	530	470
	17.5	16800	13440	11200	9600	8400	7470	6220	5140	4320	3680	3180	2430	1920	1560	1290	1080	920	790	690	610	540	480
	20.	32060	20570	14280	10490	8040	6350	5140	4250	3570	3040	2620	2010	1590	1290	1060	890	760	660	570	500		
7	17.5	24710	19100	13270	9750	7460	5900	4780	3950	3320	2830	2440	1870	1470	1190	990	830	710	610	530	470		
	15.	17500	14000	11700	9010	6900	5450	4420	3650	3070	2610	2250	1730	1360	1100	910	770	650	560	490	430		
	17.25	23280	14900	10350	7600	5820	4600	3720	3080	2590	2200	1900	1450	1150	930	770	650	550	480				
6	14.75	21120	13650	9470	6960	5330	4210	3410	2820	2370	2020	1740	1330	1050	850	700	590	500	440				
	12 25	13800	11040	8610	6320	4840	3830	3100	2560	2150	1830	1580	1210	960	780	640	540	460	400				
	14.75	16160	10340	7180	5280	4040	3190	2590	2140	1800	1530	1320	1010	800	650	530	450						
5	12.25	14530	9300	6460	4740	3630	2870	2320	1920	1610	1380	1190	910	720	580	480	400						
	9.75	10500	8250	5730	4210	3220	2550	2060	1710	1430	1220	1050	810	640	520	430	360						
	10.5	9520	6090	4230	3110	2380	1880	1520	1260	1060	900	780	590	470	380								
	9.5	9000	5760	4000	2940	2250	1780	1440	1190	1000	850	730	560	440	360								
4	8.5	8470	5420	3770	2770	2120	1670	1360	1120	940	800	690	530	420	340								
	7.5	7600	5090	3530	2600	1990	1570	1270	1050	880	750	650	500	390	320								
	7.5	5180	3310	2300	1690	1290	1020	830	680	580	490	420											
3	6.5	4780	3060	2130	1560	1200	940	770	630	530	450	390											
	5.5	4410	2820	1960	1440	1100	870	710	580	490	420	360											

Loads within heavy horizontal lines will produce excessive shear in webs.
Loads below dotted horizontal lines will produce excessive deflection.

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STRENGTH OF MATERIALS—METALS AND ALLOYS

Stresses Per Square Inch

Metals and Alloys	Stresses in Thousands of Pounds: Tension, Ultimate	Elastic Limit	Compression, Ultimate	Bending, Ultimate	Shearing, Ultimate	Modulus of Elasticity, Pounds	Elongation, %
Aluminum, cast	15	6.5	12		12	11,000,000	
" bars, sheets	24-28	12-14					
" wire, hard	30-65	16-30					
" " annealed	20-35	14					
" 2—7% Ni, Cu, Fe, etc.	40-50	25					
Aluminum Bronze, 5% to 7½% Al	75	40	120				
" " 10% Al	85-100	60					
Copper, cast	25	6	40	22	30	10,000,000	
" plates, rods, bolts	32-35	10	32				
" wire, hard	55-65					18,000,000	
" wire, annealed	36	10				15,000,000	
Brass, 17% Zn	32.6	8.2		23.2			26.7
" 23% "		7.6	42	22.3			35.8
" 30% "	28.1	8.6		26.9			20.7
" 39% "	41.1	17.4	75	39			20.7
" 50% "	31	17.9	117	33.5			5.0
" cast, common	18-24	6	30	20	36	9,000,000	
" wire, hard	80						
" " annealed	50	16				14,000,000	
Bronze 8% Sn	28.5	19	42	43.7		10,000,000	5.5
" 13% "	29.4	20	53	34.5			3.3
" 20% "	33		78	56.7			0.04
" 24% "	22	22	114	32			0
" 30% "	5.6	5.6	147	12.1			0
" gun metal, 9 Cu 1Sn	25-55	10		52		10,000,000	
" Manganese, cast } 10% Sn	60	30	125				
" " rolled } 2% Mn	100	80					
" Phosphorus, cast } 9% Sn	50	24					
" " wire } 1% P	100						
" Silicon, cast, 3% Si	55						
" " " 5% Si	75						
" " wire	108						
" Tobin, cast } 38% Zn	66						
" " rolled } 1½% Sn	80	40				4,500,000	
" " cold rolled } ½% Pb	100						
Delta Metal, cast } 55—60% Cu	43						
" " plates } 38—40% Zn	68						
" " bars } 2— 4% Fe	85						
" " wire } 1— 2% Sn	100						
German Silver, 25% Zn, 20% Ni							
Gold, cast	20	4				8,000,000	
" wire	30						
" copper, 5 Au, 1 Cu	50						
Lead, cast	1.8					1,000,000	
" pipe, wire	2.2-2.5					1,000,000	
" rolled sheets	3.3					720,000	
Platinum, wire, unannealed	53						
" " annealed	32						
Silver, cast	40						
Tin, cast	3.5-4.6	1.5-1.8	6	4		4,000,000	
" antimony, 10 Sn, 1 Sb	11						
Zinc, cast	4-6	4	18	7		13,000,000	
" rolled sheets	7-16						

Metals and Alloys	Stresses in Thousands of Pounds: Tension, Ultimate	Elastic Limit	Compression, Ultimate	Bending, Ultimate	Shearing, Ultimate	Modulus of Elasticity, Pounds	Elongation, %	Reduction of Area, %
Steel								
Structural Shapes, plates*								
" bridges	60	½ tens.	tensile	tensile	¾ tens.	29,000,000	25	
" buildings	55-65	"	"	"	"	29,000,000	25-21	
" ships	55-65	"	"	"	"	29,000,000	27-23	
Boiler Plates*								
" " flange	55-65	½ tens.	tensile	tensile	¾ tens.	29,000,000	27-23	
" " fire box	52-62	"	"	"	"	29,000,000	29-24	
" " extra soft	45-55	"	"	"	"	29,000,000	33-27	
Rivets*								
" bridges	50	½ tens.	tensile	tensile	¾ tens.	29,000,000	30	
" buildings, ships	48-58	"	"	"	"	29,000,000	29-24	
Reinforcement Bars**								
" structural, plain	55-70	33	tensile	tensile	¾ tens.	29,000,000	25-20	
" " deformed	55-70	33	"	"	"	29,000,000	22-18	
" hard, plain	80 min.	50	"	"	"	29,000,000	15	
" " deformed	80 min.	50	"	"	"	29,000,000	12.5	
" cold twisted		55	"	"	"	29,000,000	5	
Castings*								
" bridges	65	½ tens.	tensile	tensile	¾ tens.		18	
" ships	60	"	"	"	"		18	
Forgings*								
" soft, low carbon	58	29	tensile	tensile	¾ tens.		28	28
" carbon, not annealed	75	37.5	"	"	"		18	30
" " annealed	70-80	35-40	"	"	"		24-22	30-35?
" " oil tempered	80-90	45-55	"	"	"		23-20	40-45?
" locomotive	80	40	"	"	"		20	25
" nickel, annealed	80	45-50	"	"	"		24-25	40-45
" " oil tempered	85-95	55-65	"	"	"		24-21	45-50
" axles, carbon steel	80	40	"	"	"		20	25
" " nickel	80	50	"	"	"		25	45
Steel Alloys								
Nickel Steel, 3—4% Ni								
" shapes, plates	80 min.	50 min.	tensile	tensile	¾ tens.		20	
" rivets	70-85	45 min.	"	"	"		23-19	
Copper Steel, 0.5% Cu	60-68	37-38	"	"	"		23-29	48-53?
Steel Springs and Wire								
Springs, untempered	65-115	40-70						
Wire, unannealed	120	60						
" annealed	80	40						
" bridge cable	200	95						
Wrought Iron								
Shapes	48	26	tensile	tensile	5/6 tens.	28,000,000		
Bars	50	27	"	"	"	28,000,000		
Wire, unannealed	80					15,000,000		
" annealed	60	27				25,000,000		
Cast Iron								
Common	15-18	6	80	30	18-20	12,000,000		
Gray	18-24			25-33				
Malleable	27-35	15-20	46	30	40			

*See Specifications of the Society of Testing Materials, adopted August 16, 1909.

**See Specifications of the Association of American Manufacturers, adopted 1910.

STRENGTH OF BUILDING MATERIALS

Stresses in Pounds Per Square Inch

Building Materials	Ultimate Average Stresses: Compress.	Tension	Bending	Modulus of Elasticity	Safe Working Stresses: Compress.	Bearing	Shearing
Stone							
Bluestone	12,000	1,200	2,500	7,000,000	1,200	1,200	200
Granite, gneiss	12,000	1,200	1,600	7,000,000	1,200	1,200	200
Limestone, marble	8,000	800	1,500	7,000,000	800	800	150
Sandstone	5,000	150	1,200	3,000,000	500	500	150
Slate	10,000	3,000	5,000	14,000,000	1,000	1,000	175
Brick							
Common, good	10,000	200	600				
" medium burned	11,000						
" hard burned	15,000						
Pressed and paving	6,000						
Cement, Portland							
Neat, 28 days	7,040	740					
" 90 days	7,350	740					
1:3 sand, 28 days	1,290	320					
" 90 days	1,490	340					
Concrete, P. C.							
1:1½:3, hard stone	2,650						
" soft stone	1,800						
" cinders	700						
1: 2 :4, hard stone	2,100						
" soft stone	1,500						
" cinders	600						
1:2½:5, hard stone	1,700						
" soft stone	1,200						
" cinders	500						
1: 3 :6, hard stone	1,350						
" soft stone	1,000						
" cinders	400						
Masonry							
Granite					420	600	
Limestone, bluestone					350	500	
Sandstone					280	400	
Rubble					140	250	
" coursed					168	250	
Concrete, P. C., 1: 2 :4					350	600	
" " 1:2½:5					280	500	
Brick, common					168	300	
" hard burned					210	300	
Miscellaneous							
Glass, common	30,000	3,000	3,000	8,000,000			
" flooring	10,000	3,000	3,000				
Plaster	700	70					
Terra cotta	5,000						
Ropes, cast steel hoisting		80,000					
" standing, derrick		70,000					
" manila		8,000					
Belts, solid woven, cotton		7,800					
" " " flax		9,900					

Reinforced Concrete—Safe Working Stresses*

Elastic Modulus	2,000,000 if ult. compression is up to 2,200. 2,500,000 if ult. compression is over 2 200. 3,000,000 if ult. compression is over 2,900.
Compression	22.5% of ult. compression on piers or columns of lengths not exceeding 12 dia.
Bearing	32.5% of ult. compression on surfaces of at least twice the loaded area.
Shearing	2.0% of ult. compression, horizontal bars. 3.0% for reinforcement with bent-up bars. 6.0% for thoroughly reinforced webs.
Bond	4% of ult. compression for plain bars. 2% for drawn wire.

For ultimate and working stresses of Structural Timber, see page 319.

*For complete data, see Proceedings of the American Society of Civil Engineers, Vol. XXXIX, No. 2, February, 1913.

MASONRY

Stone Work

Stone walls are measured by the perch (24¾ cubic feet). Openings less than 3 feet wide are counted solid; over 3 feet are deducted, but 18 inches are added to the running measure for each jamb built. Arches are counted solid from their spring. Corners of buildings are measured twice. Pillars less than 3 feet are counted on three sides as lineal, multiplied by fourth side and depth.

It is customary to measure all foundation and dimension stone by the cubic foot. Water tables and base courses by lineal feet. All sills and lintels or ashlar, by superficial feet, and no walls less than 18 inches thick.

The greatest safe load per super. foot on:—

Granite piers	equals	40	tons.
Limestone piers	"	25	"
Sandstone piers	"	15	"
Brickwork in cement	"	3	"
Rubble masonry	"	2	"
Lime Concrete foundations	"	2½	"

The height of brick or stone piers should not exceed twelve times their least thickness at base.

Brick Work

Brick work is generally measured by 1000 brick laid in the wall. In consequence of variations in size of bricks, no rule for volume of brick can be exact. The following scale is, however, a fair average:

7 bricks to a super. foot	4" wall equals	40	lbs.
14 " " "	9" " "	94	"
21 " " "	13" " "	121	"
28 " " "	18" " "	168	"
35 " " "	22" " "	210	"

Corners are not measured twice as in stone work. Openings over 2 feet square are deducted. Arches are counted from the spring. Fancy work counted 1½ bricks for 1. Pillars are measured on their face only.

A cubic yard of mortar requires 1 cubic yard of sand and 9 bushels of lime, and will fill 30 hods.

One thousand bricks, closely stacked, occupy about 56 cubic feet.

One thousand old bricks, cleaned and loosely stacked, occupy about 72 cubic feet.

One superficial foot of gauged arches requires 10 bricks.

Stock bricks commonly measure 8¾ inches by 4¼ inches by 2¾ inches and weigh from 5 to 6 pounds each.

Paving bricks should measure 9 inches by 4½ inches by 1¾ inches, and weigh about 4½ pounds each.

One yard of paving requires 36 stock bricks, of above dimensions, laid flat, or 52 on edge; and 35 paving brick laid flat, or 82 on edge.

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Miscellaneous Building Data.

WEIGHTS OF VARIOUS MATERIALS

Material	Average Per Cu. Ft. Pounds
BRICK	
Common red	100
Fire clay	150
Silica	128
Chrome	175
Magnesia as brick or fused in furnace	160
CEMENT	
Portland	78
Hydraulic	60
FINE GROUND CLAYS, SILICA, CEMENT, ETC.	
Fire clay	85
Silica cement	75
Magnesia cement	127
Chrome cement	135
Grain magnesite (as shipped)	112
COAL AND COKE	
Anthracite	60
Bituminous	49
Charcoal	18.5
Coke	26.3
CONCRETE	
Cement, fine	137
Rubble, coarse	119
EARTH	
Loam, dry, loose	76
Loam, packed	95
Loam, soft, loose mud	108
Loam, dense mud	125
GLASS	
Common window	157
Plate	172
Flint	192
Floor or skylight	158
GRAIN	
Corn	45
Oats	24
Wheat	48
LIME	
Quick, loose lumps	53
Quick, fine	75
Stone, large rocks	168
Stone, irregular lumps	96
MASONRY	
Granite or limestone	165
Mortar, rubble	154
Dry	138
Sandstone, dressed	144
METALS	
Aluminum	166
Brass, cast	524
Bronze	534
Copper, cast	537
Copper, rolled or wire	555
METALS—Continued	
Iron, cast	450
Iron, wrought	482
Lead, cast	708
Lead, rolled	711
Steel, cast	490
Steel, rolled	495
Tin, cast	459
Zinc, cast	438
OILS	
Engine	55
Crude	48
Petroleum	55
Gasoline	43
ROCK	
Chalk	145
Granite	165
Gypsum	143
Sandstone	144
Pumice Stone	57
Quartz	165
Salt, coarse	45
Salt, fine	49
Shales	162
Slate, American	175
SAND	
Dry and loose	100
Dry and packed	110
Wet and packed	130
Gravel packed	118
WATER	
Water as ice	58.7
Water at 32 degrees Fahrenheit	62.4
Water at 212 degrees Fahrenheit	59.6
WOODS, DRY	
Apple	48
Beech	43
Birch	45
Cedar, American	35
Chestnut	41
Ebony	76
Elm	35
Hemlock	25
Hickory	53
Ironwood	114
Mahogany	35 to 53
Maple	49
Oak live	59
Oak, white	50
Pine, white	25
Pine, yellow northern	34
Pine, yellow southern	45
Spruce	25
Walnut	35

PAINT

One gallon of paint will cover 250 to 400 sq. ft. as a first coat, depending on the character of the surface, and from 350 to 500 sq. ft. as a second coat.

PLASTER

One thousand laths will cover 70 sq. yds. of surface, and 7 lbs. of lath nails will nail them on. Eight bushels of good lime, 16 bushels of sand, and one bushel of hair will make enough good mortar to plaster 100 square yards.

HAIR

1½ bushels will do 100 square yards of plastering.

LATH

For 100 square yards, 1,500 lath are required.

SAND

⅝ of a yard is required for every barrel of lime.

LIME

2 bbls. will plaster 100 square yards, one coat.

3½ bbls. will plaster 100 square yards, two coats.

1 bbl. will lay 1,000 brick, but must be good lime.

½ bbl. will lay one perch of rubble stone.

2 bbls. will lay one cord of rubble stone.

3 bbls. will lay 100 cubic feet of wall.

WEIGHTS AND ANGLES OF REPOSE

Various Kinds of Loose and Dry Materials

Kind of Material	Size of Material	Ratio of Slope	Angle of Repose	Weight per Cu. Ft. Pounds
Ashes, dry		1 on 1	45°	40
Cinders, bituminous, dry		1 on 1	45°	45
Clay, in, lumps, dry		1 on 1⅓	36° 52′	63
Clay, damp, plastic		1 on 3	18° 26′	110
Clay and gravel, dry		1 on 1⅓	36° 52′	100
Clay, gravel and sand, dry		1 on 1⅓	36° 52′	100
Coal, anthracite		1 on 1	45°	97
Coal, bituminous		1 on 1	45°	84
Coal, coke		1 on 1	45°	75
Coal, anthracite, in pile, loose		1 on 1⅓	36° 52′	53
Coal, bituminous, in pile, loose		1 on 1⅓	36° 52′	47
Coal, coke, in pile, loose		1 on 1⅓	36° 52′	23
Earth, perfectly dry, loose		1 on 1⅓	36° 52′	76
Earth, perfectly dry, packed		1 on 1⅓	36° 52′	95
Earth, slightly moist, loose		1 on 1⅓	36° 52′	78
Earth, more moist, packed		1 on 1	45°	96
Earth, soft flowing mud		1 on 3	18° 26′	108
Earth, soft mud packed		1 on 3	18° 26′	115
Gravel, dry	1″ and less	1 on 1⅓	36° 52′	104
Gravel, dry	Up to 2½″	1 on 1⅓	36° 52′	96
Limestone fragments, dry	1″ and less	1 on 1	45°	85
Limestone fragments, dry	Up to 2½″	1 on 1	45°	80
Sand, clean and dry		1 on 1½	33° 41′	90
Sand, river, dry		1 on 1½	33° 41′	106
Sandstone fragments		1 on 1	45°	90
Shale fragments		1 on 1⅓	36° 52′	105

SHINGLES REQUIRED IN A ROOF

Double the rafters and multiply by length of building. Multiply this by 9 if exposed 4 inches, by 8 if exposed 4½ inches, and by 7⅕ if exposed 5 inches, to the weather.

Two thousand shingles laid 4 inches to the weather will cover 200 square feet of roof, and 10½ pounds 4-penny nails will fasten them.

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Miscellaneous Building Data---Continued

BOARD MEASURE

Number of Board Feet Per Lineal Foot for Various Widths and Thicknesses

Width of Board, In.	Thickness of Board, Inches												
	1	1½	2	2½	3	3½	4	5	6	7	8	9	10
3	0 250	0.375	0.500	0.625	0 750	......	......	......	......	......	......	......	......
3½	292	.438	.583	.729	.875	1.021	......	......	......	......	......	......	......
4	333	500	.667	.833	1 000	1 167	1.333	......	......	......	......	......	......
4½	375	563	.750	938	1 125	1.313	1.500	......	......	......	......	......	......
5	417	625	.833	1 042	1 250	1.457	1.666	2.083	......	......	......	......	......
6	.500	750	1 300	1.250	1 500	1.750	2.000	2.500	3.000	......	......	......	......
7	583	875	1 167	1 458	1.750	2.042	2.333	2.917	3.500	4.083	......	......	......
8	667	1 000	1 333	1 667	2 000	2.333	2.667	3.333	4.000	4.667	5.333	......	......
9	750	1 125	1 500	1.875	2.250	2.625	3.000	3.750	4.500	5.250	6.000	6.750	......
10	833	1.250	1 667	2.083	2.500	2.917	3.333	4.167	5.000	5.833	6.667	7.500	8.333
11	917	1.375	1 833	2.292	2.750	3.208	3.667	4.583	5.500	6.417	7.333	8.250	9.167
12	1 000	1.500	2.000	2.500	3.000	3.500	4.000	5.000	6.000	7.000	8.000	9.000	10.00
13	1.083	1 625	2.167	2.708	3 250	3.792	4.333	5.417	6.500	7.583	8.667	9.750	10.83
14	1 167	1.750	2.333	2.917	3.500	4.083	4.667	5.833	7.000	8.167	9.333	10.50	11.67
15	1 250	1 875	2.500	3.125	3.750	4.375	5.000	6.250	7.500	8.750	10.00	11.25	12.50
16	1 333	2 000	2 667	3 333	4.000	4 667	5.333	6.667	8.000	9.333	10.67	12.00	13.33
18	1 500	2.250	3.000	3.750	4.500	5 250	6.000	7.500	9.000	10.50	12 00	13.50	15.00
20	1 667	2 500	3 333	4 167	5 000	5 833	6.667	8.333	10.00	11.67	13.33	15.00	16.67

LUMBER TABLE

For convenience the number of Board Feet in Single Pieces of the Commercial Sizes are given below.

Size in inches	Lengths in Feet							
	10	12	13	14	16	18	20	22
1 x 2	1⅔	2	2⅙	2⅓	2⅔	3	3⅓	3⅔
1 x 3	2½	3	3¼	3½	4	4½	5	5½
1 x 3½	2 11/12	3½	3 19/24	4 1/12	4⅔	5¼	5⅚	6 5/12
1 x 4	3⅓	4	4⅓	4⅔	5⅓	6	6⅔	7⅓
1 x 5	4⅙	5	5 5/12	5⅚	6⅔	7½	8⅓	9⅙
1 x 6	5	6	6½	7	8	9	10	11
1 x 8	6⅔	8	8⅔	9⅓	10⅔	12	13⅓	14⅔
1 x 9	7½	9	9¾	10½	12	13½	15	16½
1 x 10	8⅓	10	10⅚	11⅔	13⅓	15	16⅔	18⅓
1 x 12	10	12	13	14	16	18	20	22
1 x 13	10⅚	13	14 1/12	15⅙	17⅓	19½	21⅔	23⅚
1 x 14	11⅔	14	15⅙	16⅓	18⅔	21	23⅓	25⅔
1¼ x 3	3⅛	3¾	4 1/16	4⅜	5	5⅝	6¼	6⅞
1¼ x 4	4⅙	5	5 5/12	5⅚	6⅔	7½	8⅓	9⅙
1¼ x 5	5 5/24	6¼	6 37/48	7 7/24	8⅓	9⅜	10 5/12	11 11/24
1¼ x 6	6¼	7½	8⅛	8¾	10	11¼	12½	13¾
1¼ x 8	8⅓	10	10⅚	11⅔	13⅓	15	16⅔	18⅓
1¼ x 9	9⅜	11¼	12 3/16	13⅛	15	16⅞	18¾	20⅝
1¼ x 10	10 5/12	12½	13 13/24	14 7/12	16⅔	18¾	20⅚	22 11/12
1¼ x 12	12½	15	16¼	17½	20	22½	25	27½
2 x 3	5	6	6½	7	8	9	10	11
2 x 4	6⅔	8	8⅔	9⅓	10⅔	12	13⅓	14⅔
2 x 9	15	18	19½	21	24	27	30	33
2 x 10	16⅔	20	21⅔	23⅓	26⅔	30	33⅓	36⅔
4 x 4	13⅓	16	17⅓	18⅔	21⅓	24	26⅔	29⅓
5 x 5	20⅚	25	27 1/12	29⅙	33⅓	37½	41⅔	45⅚
6 x 6	30	36	39	42	48	54	60	66
8 x 8	53⅓	64	69⅓	74⅔	85⅓	96	106⅔	117⅓
8 x 10	66⅔	80	86⅔	93⅓	106⅔	120	133⅓	146⅔

STRENGTH OF TIMBER

Safe Loads in Tons, Uniformly Distributed, for White Oak Beams

Formula: $W = \frac{4PBD^2}{3L}$

W—safe load in pounds: P, extreme fibre-stress—1000 lbs. per square inch, for white oak; B, breadth in inches; D, depth in inches; L, distance between supports in inches.

Size of Timber	Distance Between Supports in Feet — Safe Load in Tons of 2000 Pounds														
	6	8	10	11	12	14	15	16	17	18	19	21	23	25	26
2x 6	0.67	0.50	0.40	0.36	0.33	0.29	0.27	0.25	0.24	0.22	....	....	....	....	....
2x 8	1.19	0.89	0.71	0.65	0.59	0.51	0.47	0.44	0.42	0.40	0.37	0.34	0.31	0.28	....
2x10	1.65	1.39	1.11	1.01	0.93	0.79	0.74	0.69	0.65	0.62	0.58	0.53	0.48	0.44	0.43
2x12	2.67	2.00	1.60	1.45	1.33	1.14	1.07	1.00	0.94	0.89	0.84	0.76	0.70	0.64	0.62
3x 6	1.00	0.75	0.60	0.55	0.50	0.43	0.40	0.37	0.35	0.33	0.32	0.29	0.26	....	....
3x 8	1.78	1.33	1.07	0.97	0.89	0.76	0.71	0.67	0.63	0.59	0.56	0.51	0.46	0.43	0.41
3x10	2.78	2.08	1.67	1.52	1.39	1.19	1.11	1.04	0.98	0.93	0.88	0.79	0.72	0.67	0.64
3x12	4.00	3.00	2.40	2.18	2.00	1.71	1.60	1.50	1.41	1.33	1.26	1.14	1.04	0.96	0.92
3x14	5.45	4.08	3.27	2.97	2.72	2.37	2.18	2.04	1.92	1.82	1.72	1.56	1.42	1.31	1.25
3x16	7.11	5.33	4.27	3.88	3.56	3.05	2.84	2.67	2.51	2.37	2.25	2.03	1.86	1.71	1.64
4x10	3.70	2.78	2.22	2.02	1.85	1.59	1.48	1.39	1.31	1.23	1.17	1.06	0.97	0.89	0.85
4x12	5.33	4.00	3.20	2.91	2.67	2.29	2.13	2.00	1.88	1.78	1.68	[illegible]	1.39	1.28	1.23
4x14	7.26	5.44	4.36	3.96	3.63	3.11	2.90	2.72	2.56	2.42	2.29	2.07	1.90	1.74	1.68
4x16	9.48	7.11	5.69	5.17	4.74	4.06	3.79	3.56	3.35	3.16	3.00	2.71	2.47	2.28	2.19
4x18	12.00	9.00	7.20	6.55	6.00	5.14	4.80	4.50	4.24	4.00	3.79	3.43	3.13	2.88	2.77

For other kinds of wood than white oak multiply the figures in the table by a figure selected from those given below (which represents the safe stress per square inch on beams of different kinds of wood according to the building laws of the cities named) and divide by 1000

	Hemlock	Spruce	White Pine	Oak	Yellow Pine
New York	800	900	900	1100	1100*
Boston	.....	750	750	1000†	1250
Chicago	.....	.....	900	1080	1440

*Georgia Pine. †White Oak.

SPECIFIC GRAVITY AND WEIGHT OF WOOD

	Specific Gravity	Average Specific Gravity	Weight per Cubic Foot Pounds
Alder	0.56 to 0.80	0.68	42
Apple	.73 to .79	.76	47
Ash	.60 to .84	.72	45
Bamboo	.31 to .40	.35	22
Beech	.62 to .85	.73	46
Birch	.56 to .74	.65	41
Box	.91 to 1.33	1.12	70
Cedar	.49 to .75	.62	39
Cherry	.61 to .72	.66	41
Chestnut	.46 to .66	.56	35
Cork	.24 to	.24	15
Cypress	.41 to .66	.53	33
Dogwood	.76 to	.76	47
Ebony	1.13 to 1.33	1.23	76
Elm	.55 to .78	.61	38
Fir	.48 to .70	.59	37
Gum	.84 to 1.00	.92	57
Hackmatack	.59 to	.59	37
Hemlock	.36 to .41	.38	24
Hickory	.69 to .94	.77	48
Holly	.76 to	.76	47
Hornbeam	.76 to	.76	47
Juniper	.56 to	.56	35
Larch	.56 to	.56	35
Lignum Vitae	.65 to 1.33	1.00	62
Linden	.604 to	....	37
Locust	.728 to	....	46
Mahogany	.56 to 1.06	.81	51
Maple	.57 to .79	.68	42
Mulberry	.56 to .90	.73	46
Oak, Live	.96 to 1.26	1.11	69
Oak, White	.69 to .86	.77	48
Oak, Red	.73 to .75	.74	46
Pine, White	.35 to .55	.45	28
Pine, Yellow	.46 to .76	.61	38
Poplar	.38 to .58	.48	30
Spruce	.40 to .50	.45	28
Sycamore	.59 to .62	.60	37
Teak	.66 to .98	.82	51
Walnut	.50 to .67	.58	36
Willow	.49 to .59	.54	34

WINDOW GLASS

Thickness and Weight per Square Foot

No.	Thickness	Weight	No.	Thickness	Weight	No.	Thickness	Weight
12	.059 in.	12 oz.	17	.083 in.	17 oz.	26	.125 in.	26 oz.
13	.063 in.	13 oz.	19	.091 in.	19 oz.	32	.154 in.	32 oz.
15	.071 in.	15 oz.	21	.1 in.	21 oz.	36	.167 in.	36 oz.
16	.077 in.	16 oz.	24	.111 in.	24 oz.	42	.2 in.	42 oz.

WIND PRESSURE ON ROOFS

Pounds to a Square Foot

Rise, Inches in a Foot of Run	Angle with Horizontal	Pitch Proportion Rise to Span	Wind Pressure Normal to Slope
4	18° 25′	⅙	16.8
6	26° 33′	¼	23.7
8	33° 41′	⅓	29.1
12	45° 0′	½	36.1
16	53° 7′	⅔	38.7
18	56° 20′	¾	39.3
24	63° 27′	1	40.0

SNOW AND WIND LOADS

Data in regard to snow and wind loads is necessary in connection with the design of roof trusses.

Snow Load—When the slope of a roof is over 12 inches rise in a foot of horizontal run, a snow and accidental load of 8 pounds to a foot is ample. When the slope is under 12 inches rise to a foot of run, a snow and accidental load of 12 pounds to a square foot should be used. The snow load acts vertically, and should therefore be added to the dead load in designing roof trusses. The snow load may be neglected when a high wind pressure has been considered, as a great wind storm would very likely remove all the snow from the roof.

Wind Load—The wind is considered as blowing in a horizontal direction, but the resulting pressure upon the roof is always taken normal (at right angles) to the slope.

Table above gives the pressure exerted upon roof of different slopes, by a wind pressure of 40 pounds to a square foot on a vertical plane, which is equivalent to the intensity of a violent hurricane.

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Data on Concrete

MIXTURES RECOMMENDED FOR VARIOUS TYPES OF CONCRETE WORK

Concrete

1:2:3 mixture for:
One-course concrete walks and pavements.
One-course floors.
Roofs.
Fence posts, mine timbers and sills, and lintels without mortar surface.
Water troughs and tanks.

1:2:4 mixture for:
Reinforced concrete floors, beams and columns.
Large engine foundations.
Work exposed to vibration.

1:2½:4 mixture for:
Building walls and foundations of underground workings.
Backing of concrete block and similar cement products.

1:2½:5 mixture for:
Basement walls and foundations of above ground structures.
Small engine foundations.
Base of sidewalks and two-course floors.

1:3:5 mixture for:
Mass concrete footings.

Mortar

1:1 mixture for:
Facing water tanks.

1:1½ mixture for:
Wearing course of two-course floors.

1:2 mixture for:
Scratch coat of exterior plaster.
Facing blocks and similar cement products.
Wearing course of two-course walks, street and highway pavements.

1:2½ mixture for:
Finish coat, exterior plaster.
Fence posts, when coarse aggregate is not used.

1:3 mixture for:
Concrete blocks, when coarse aggregate is not used.
Cement drain tile, when coarse aggregate is not used.

Water used in mixing concrete should be clean and free from organic matter. The amount required depends largely upon the character of the work to be done. Wherever possible, it is desirable to mix concrete to a "quaky" consistency, so that the mass will readily settle into all parts of the forms in which it is being placed, with a minimum amount of puddling or tamping. If too much water is used the cement-sand mortar will separate from the coarse aggregate. Also, if the forms are not watertight, water will flow out and carry a good deal of cement with it, thus robbing the concrete of its most vital constituent.

QUANTITIES OF SAND AND GRAVEL OR STONE REQUIRED FOR A ONE-BAG BATCH OF MORTAR OR CONCRETE, AND VOLUME OF RESULTING COMPACTED MORTAR OR CONCRETE

MIXTURES			MATERIALS			VOL. IN CU. FT.	
Cement	Sand	Gravel or Stone	Cement in Sacks	Sand Cubic Feet	Gravel or Stone Cubic Feet	Mortar	Concrete
1	1.5	....	1	1.5	....	1.75	....
1	2	....	1	2.0	....	2.1	....
1	2.5	....	1	2.5	....	2.8	....
1	3	....	1	3.0	....	2.8	....
1	2	3	1	2	3	....	3.9
1	2	4	1	2	4	....	4.5
1	2.5	4	1	2.5	4	....	4.8
1	3	5	1	3	5	....	5.8

QUANTITIES OF CEMENT, SAND AND GRAVEL OR STONE REQUIRED FOR ONE CUBIC YARD OF COMPACTED MORTAR OR CONCRETE

MIXTURES			QUANTITIES OF MATERIALS				
				Sand		Stone or Gravel	
Cement	Sand	Gravel or Stone	Cement in Sacks	Cubic Feet	Cubic Yards	Cubic Feet	Cubic Yards
1	1.5	....	15.5	23.2	.86	....	....
1	2	....	12.8	25.6	.95	....	....
1	2.5	....	11.0	27.5	1.02	....	....
1	3	....	9.6	28.8	1.07	....	....
1	2	3	7.0	14.0	.52	21.0	.78
1	2	4	6.0	12.0	.44	24.0	.89
1	2.5	4	5.6	14.0	.52	22.4	.83
1	3	5	4.6	13.8	.51	23.0	.85

Stone and gravel equal 45 per cent. voids (average); 1 sack cement equals 1 cubic foot; 4 sacks equal 1 barrel.
Based on tables in "Concrete, Plain and Reinforced," by Taylor & Thompson.

Particles of aggregate which will pass a ¼-inch screen (one having 4 meshes per lineal inch) are considered as sand; coarse aggregate, either screened gravel or crushed stone, shall all be coarser than ¼-inch, and for ordinary work the maximum diameter should not exceed 1½ inches. One sack of Portland cement (94 pounds net) is considered 1 cubic foot, and each batch of concrete should be some multiple of 1 sack. A 1:2:4 mixture, therefore, means 1 sack of Portland cement, 2 cubic feet of sand, and 4 cubic feet of gravel or broken stone; sand and gravel to conform as regards size, grading and cleanliness, to the specifications already given.

* * * *

The strength of concrete increases considerably with age. For example a Portland cement concrete 1 month old will crush under a load of about 15 tons per square foot, while if it is a year old it will sustain about 100 tons per square foot. These figures under favorable conditions may be nearly doubled. Natural cement concretes, with various proportions of materials and of ages from 6 months to 4 years, showed crushing strengths of from 70 to 100 tons per square foot.

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SOME USEFUL KNOTS FOR ENGINEERS*

The knots described in this series of articles have been useful to me in my work in out-of-the-way places. Fig. 1 indicates the meaning of the terms employed.

Fig. 2, Simple or Overhand Knot—This is the simplest of all knots to tie, and may be used as a stop on a rope. A free end is necessary to make it. If strained, it injures the fiber of the rope more than a figure-8 knot, and it is difficult to unmake and liable to jam.

Fig. 3, Double Overhand Knot—This knot is used for the end of a rope when it is required to prevent its going through an eye, as in a pulley block, or for the end of a halter rope. It is also useful for shortening a rope. It may be made with any number of turns: A in the illustration shows the first position; B, the knot finished with two turns; and C, one with four full turns of rope.

Fig. 4, Figure-8 Knot (Flemish)—This knot may be employed as a stop on a rope; is less injurious to the fiber of the rope, and more easily undone than either the single or double overhand knot. If made with the rope doubled and the bight left long, it becomes a figure-8 hoop knot.

Fig. 5, Stevedore Knot—The end of the rope is wrapped twice around the standing and then passed through the eye. It is useful as a stop on a rope to prevent the end going through an eye, as in a pulley block (see double overhand knot). It is also employed instead of sewing the rope ends with twine.

Fig. 6, Boat Knot (Marline-spike Hitch)—Suitable for quickly making a rope ladder, or getting a temporary pull on a rope with a marline-spike. No free ends are required to form this knot. The point marked A must always be at the back of the spike or rung of the ladder, away from the direction of the weight or pull.

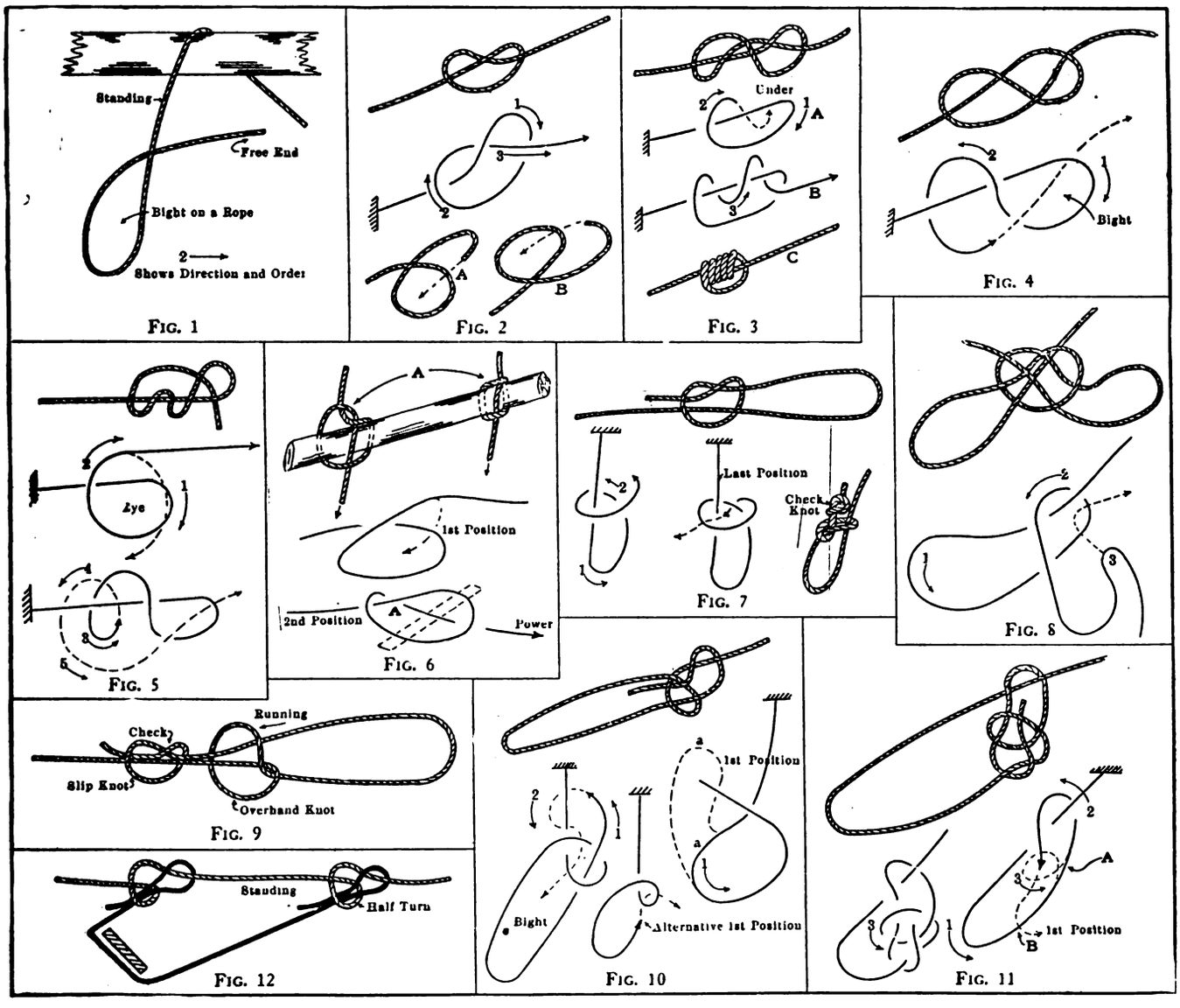

FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6 FIG. 7 FIG. 8 FIG. 9 FIG. 10 FIG. 11 FIG. 12

Simple, Stop and Slip Knots, Ladder Hitch and Bowlines

*A Livingston Oke, in Eng. and Min. Journal.

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Fig. 7, Slip Knot (Simple Running Knot)—The simplest kind of slip knot. It may be used similarly to the packer's knot (described elsewhere in this article), but is not so good, as it is liable to pull through and does not bind on the rope.

Fig. 8, Tomfool Knot (Double Running Knot)—When the loops are drawn taut and the ends tied, this makes a pair of handcuffs which it is almost impossible for the person so secured to undo. It may be used as a barrel sling, half-hitches being put on the ends, and the hook put under the knot itself. The bight marked 3 is passed through the overhand loop as shown by the dotted line.

Fig. 9, Flemish Loop—This knot makes a simple loop for light work and may be used in the same way as a bowline, but is not so quickly made; neither is it so secure nor so easily undone. The security depends almost entirely upon the check knot.

Fig. 10, Bowline—A generally useful knot when a loop of any sort that will not slip is required, as in a sling for lowering a man, or fastening a bucket to a rope.

Fig. 11, Running Bowline—As shown in the first position a half turn is made at A (shown dotted) and the end passed through and to the back of the part marked B. This is a good slip knot and does not tighten on the standing, always remaining open.

Fig. 12, Bowline II—A method of attaching the end of one rope to the standing of another. A half turn is put in the standing and the end of the other rope taken through as in tying an ordinary bowline. The knot is practically a sheet bend.

Fig. 13, Bowline on a Bight—The part marked A is passed behind B and then in the direction of the arrow to C. The bight B is then pulled taut. The two loops of this knot may be used as a man sling, a barrel sling, or as a double man-harness, one loop under each shoulder. When tightened it will not slip.

In using this knot for lowering a man into native or other old workings in countries where snakes are encountered, it is well to put only one leg through the two loops. Also, in case of an injured man, one of the loops can be kept shorter than the other and adjusted under the arm-pits, the man being seated in the larger loop. This may also be done to allow freedom for the arms when taking samples in winzes or shafts.

Fig. 14, Open-hand Loop Knot and Figure-8 Loop Knot—The upper loop knot is the one in common use and is adapted principally for small ropes. The lower, or Figure-8 knot, is a better form and may be used on a larger rope as it injures the fiber less than the common form. These knots require

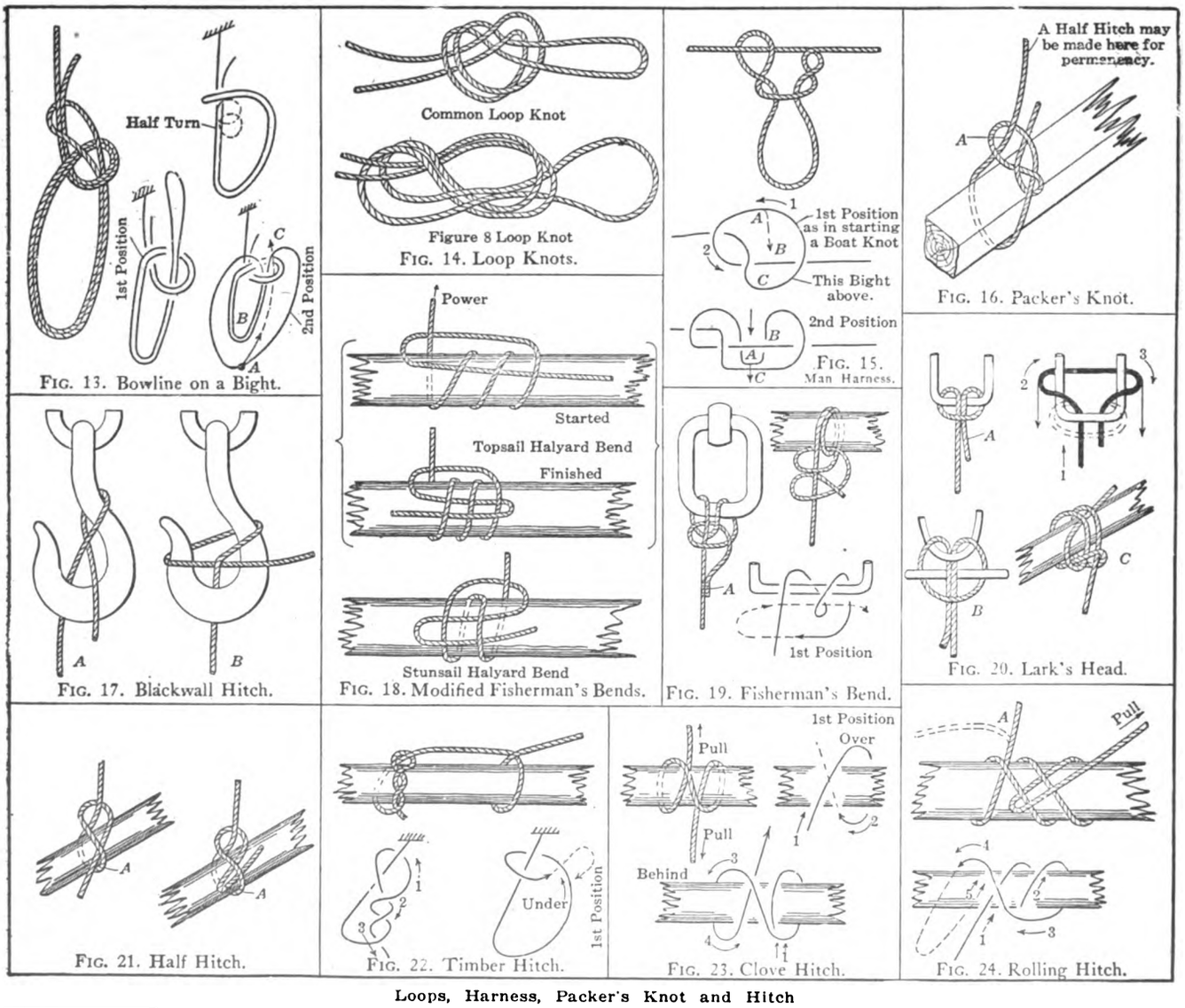

FIG. 13. Bowline on a Bight.
FIG. 14. Loop Knots.
FIG. 15. Man Harness.
FIG. 16. Packer's Knot.
FIG. 17. Blackwall Hitch.
FIG. 18. Modified Fisherman's Bends.
FIG. 19. Fisherman's Bend.
FIG. 20. Lark's Head.
FIG. 21. Half Hitch.
FIG. 22. Timber Hitch.
FIG. 23. Clove Hitch.
FIG. 24. Rolling Hitch.

Loops, Harness, Packer's Knot and Hitch

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a greater length of rope than the bowline, but may be used in similar ways.

Fig. 15, Man-harness Knot—This knot can be tied in a rope with neither end free. The bight A is pulled through under B and over C, and the knot pulled taut. It is useful as allowing a number of men to get a good purchase on a rope for hauling; also to put loops in the rope to receive hooks at points other than the ends.

Fig. 16, Packer's Knot—This knot is a modification of a simple slip knot, but has the advantage, when pulled tight, of biting on the standing at A and not easily slipping back. It is particularly useful for cording up rolls of camp bedding, etc. It can be made permanent by an added half hitch on the standing.

Fig. 17, Blackwall Hitch—A simple method for returning an empty rope on a hook. With a greasy rope, method B holds better.

Fig. 18, Modified Fisherman's Bends—These are given as alternatives for securing ropes to poles or bars, and are adapted to heavy strains.

Fig. 19, Fisherman's Bend—This is a better method than the gooseneck or lark's head (Fig 20) for securing a rope to a chain or link. It is also used to fasten the rope to a bar or the bail of a bucket. Lashing at A is necessary to prevent pulling through. As shown in first position, two turns are taken over the link and the end brought back in front and passed through the turns as shown dotted.

Fig. 20, Lark's Head—This knot is useful for fastening a rope to the link of a chain or to a ring in a wall or box. It is not a secure knot unless lashed at A. B shows a toggle inserted to prevent slipping. C is a modified gooseneck on a bar, suitable for securing the end of a rope in scaffolding. The end must be placed at the back and the whole pulled taut.

Fig. 21, Half Hitch—A quick and simple way of securing a rope to a timber when no great pull is expected. The rope end is placed under the pole, then back over the right as shown. The end must always be placed right at the back away from the pull, as shown at A. The right-hand sketch shows the hitch with a slip to facilitate undoing.

Fig. 22, Timber Hitch—This is the best and simplest of all timber hitches and may be used for towing or otherwise handling timber, rods, pipes, etc.; also for starting lashings on scaffolding or any kind of pole work. For raising or lowering timber, the half hitch should be placed high above the center of gravity to avoid slanting.

Fig. 23, Clove Hitch—This is one of the most useful of all hitches, as it will take a strain in either direction without slackening. It is used for mooring ships, heads of derricks for guy lines and all kinds of rigging work. It is easily undone, or a bight may be put in instead of one end to use as a slip. When commencing to tie the hitch on a horizontal bar, the rule is over and back below, or the reverse of the procedure in tying a half hitch.

Fig. 24, Rolling Hitch—This lashing is used for getting a grip on a large rope with a smaller one. Made in chain it can be applied to wire ropes and will not slip when the load has been taken up. It is also suitable for hauling on electric cables, or withdrawing diamond-drill or other rods. For securing the end A may be brought down and lashed to the large rope. In making, the end is passed over the spar twice, then returned back as shown at (3), then over behind as at (4), and up and under as at (5).

Fig. 25, Open-Hand Knots—These knots are useful for tying small ropes and cords together. A shows the two rope ends laid together and a simple knot tied in them. It is bulky and bad for the rope, and has nothing in its favor but the facility with which it can be tied. When tied with a Flemish knot B, the rope is not injured so much when strained, but the knot is even bulkier than the first form.

Fig. 26, Fisherman's and Hawser Knots—These knots serve the same purpose and are less bulky than the open-hand knots. A is mostly used for joining fishing lines, and it may be whipped or served as shown to prevent the ends coming together. B is suitable for large ropes. A simple knot is made on one end and the other end then taken around as shown by the dotted lines. It may also be made on a figure-8 knot as shown at C.

Fig. 27, Square or Reef Knot—This is the most commonly used knot for joining ropes of equal size when not of very large diameter. When properly tied it is fairly easily undone. The left-hand end is always placed over the one at the right, then passed under and once more over. The right-hand end is then brought around and the left-hand end passed over and under it.

Fig. 28, Sheet Bend or Weaver's Knot—The best knot for small cord, twine or fish line. This knot is also suitable for joining two ropes of unequal size where no great strain is expected. At A one of the ends is shown taken twice around the bight of the other rope to prevent jamming. B is a sheet bend with toggle to facilitate untying.

Fig. 29, Carrick Knot—Employed for joining heavy ropes. The ends must be lashed to prevent the knot pulling together and to facilitate untying. The dotted line in second position indicates how black is pulled over black and then under white at A.

Fig. 30, Double Carrick Knot—Used similarly to the carrick knot, and suitable for equal or unequal ropes. When the ends are lashed it remains open under strain and is easily undone.

Fig. 31, Other Forms of Carrick—These knots are especially adapted to heavy ropes.

Fig. 32, Hawser Bends—These bends are for joining heavy ropes. The bowline bend shown at A is strong and reliable, but takes considerable length of rope. The half-hitch bend B makes an excellent permanent joint on heavy ropes.

Fig. 33, Wall Knot—For finishing off a rope end. As shown in first position, the three ends are bent round as shown and then each in rotation is taken in the direction of the dotted lines. At A, the knot is shown started and ready for drawing tight; at B it is ready for crowning; and at C it is crowned and ready for tightening to complete the knot.

Fig. 34, Shroud Knot—This is a useful method for joining rope ends to make a sling or instead of a short splice. As shown at A, a wall knot is started in the white rope, then the strands of the black rope are passed through the loops; another wall knot is then made with the black strands, and the two knots tightened up. A further wall may then be made on each side of the joint, or as many as may be desired.

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Fig. 35, Chain Knot—This method of shortening a rope has the advantage that when the toggle is pulled out the rope entirely undoes itself under a slight strain. It is more injurious to the rope than the sheep shank. In the diagram, the part marked A, shown dotted, is pulled through the half turn to position B. C is then pulled through to make the next loop. An alternative method D is shown for use instead of a toggle.

Fig. 36, Sheep Shank—This is a quick and effective method of shortening a rope. No free end is required. Either a half hitch or boat knot may be used, and the loops may be lashed or secured by a toggle as shown. The first position A is as in making a bowline; the second position C shows one end finished. A half hitch is put in the end D, and the bight E is passed through it as shown. B shows the alternative method, employing a boat knot.

Fig. 37, Slipping Lines—A method of attaching a rope to a spar or post is shown at A. For heavy strains the toggle should be smooth and tapered. B is a slipline arranged with two bowlines and a toggle. C is a half hitch with a slip; a clove hitch may be similarly employed. D is a slip on a slip knot. It can be used when the knot has to be made on the line before it is placed over the bar or post. In the arrangement with two bowlines shown in E, less strain comes on the toggle than in B and it is more easily slipped.

Fig. 38, Derrick Head—Two clove hitches are employed as shown in A for two sets of lines. If it is desired that the lines should leave the pole from opposite sides, further half hitches may be put on until the overlaying of the turns brings the end around as shown in B.

Fig. 39, Two-leg Derrick—In A is shown the lashing started with a timber hitch and the end drawn through between the two poles. After the legs have been opened out, one or two turns are taken around vertically between the poles to bind the other turns together, and the lashing finished off with a clove hitch as in B.

Fig. 40, Three-leg Derrick—The lashing is started with a timber hitch on one pole. The three poles are then laid together as in A and as many turns as required are taken around them. The rope end is temporarily pulled through the poles as shown. The three legs are then slightly spread and the turns around the poles are bound together by further vertical turns x in B. The lashing is then finished off with a clove hitch.

Fig. 41, Building up Poles—To build up a double pole to form a gin pole, the ends are butted and joints broken as shown in A. Lashings are put on at either side of each joint. The same method is

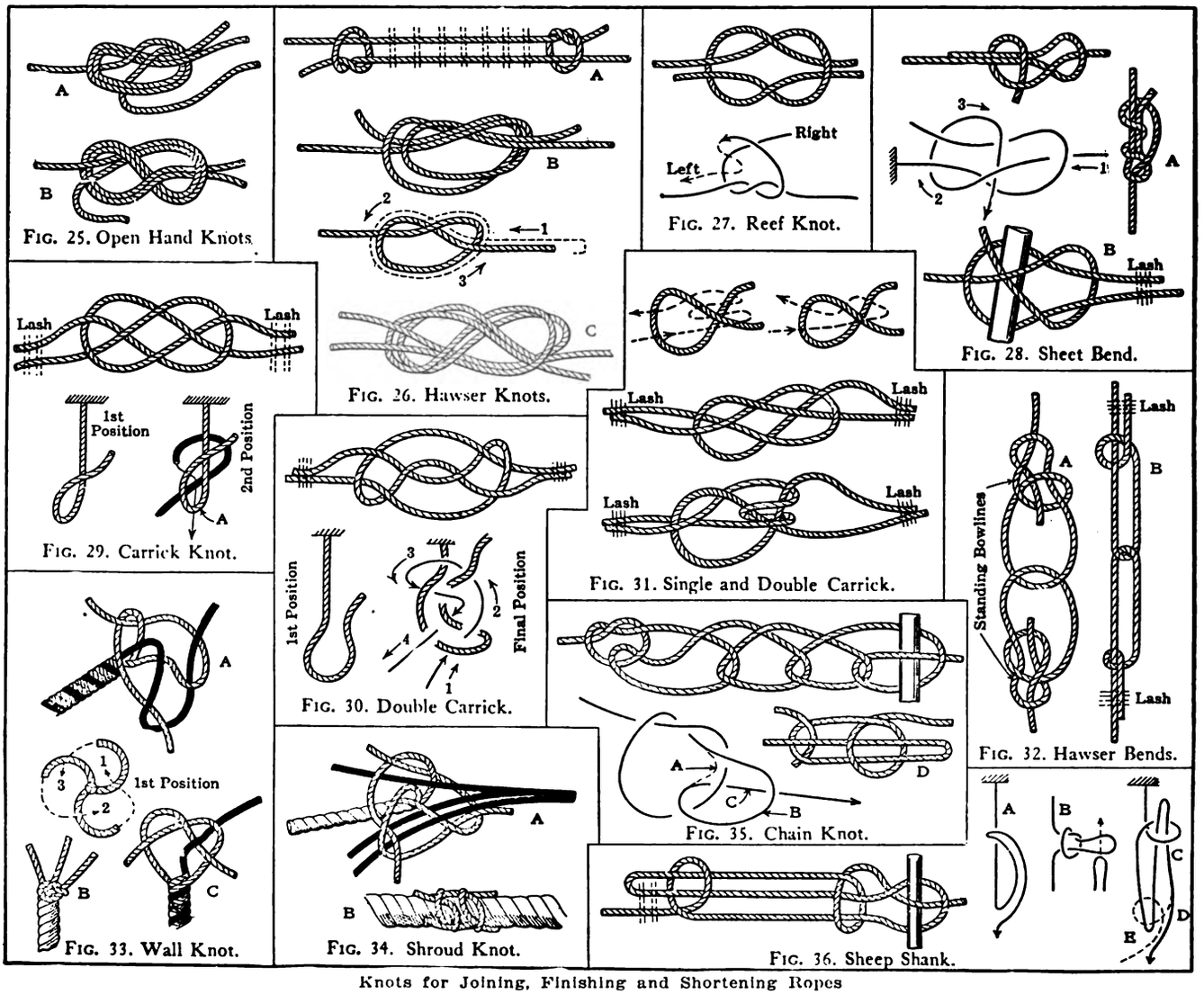

Fig. 25. Open Hand Knots. Fig. 26. Hawser Knots. Fig. 27. Reef Knot. Fig. 28. Sheet Bend. Fig. 29. Carrick Knot. Fig. 30. Double Carrick. Fig. 31. Single and Double Carrick. Fig. 32. Hawser Bends. Fig. 33. Wall Knot. Fig. 34. Shroud Knot. Fig. 35. Chain Knot. Fig. 36. Sheep Shank.

Knots for Joining, Finishing and Shortening Ropes

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employed with three poles, as shown diagrammatically at B.

Fig. 42, Pole Lashing—The bight is laid as shown in the lower sketch, and, after a sufficient number of turns are made, the end B is taken over outside the turns and put through the bight. End A is also put through the bight, and the whole tightened.

Fig. 43, Pole Lashing—This form of lashing is shown started at A, then the end is brought over and passed back under the turns as in B, and the lashing finished as in C.

Fig. 44, Scaffold Lashing—This is a lashing for holding a crosspiece in place when the strain is from above and not laterally. Less rope is required, but it does not lend itself to being tightened as well as the usual method, Fig. 45.

Fig. 45, Scaffold Lashing. This lashing is started with a timber hitch and is shown diagrammatically at A. B shows the first stage of lashing with only two turns complete, and C shows a side view of the finished lashing. If desired, wedges may be driven into the lashing to thoroughly tighten the turns.

Fig. 46, Whipping—A long bight is laid on the pole, turns taken around it, and the end drawn through the bight. This method of binding may be used to finish off a rope end; for binding splints to a fractured span to strengthen it; or to make the lashing on derrick heads and in scaffolding, the bight always being put well on the outside (see pole lashings).

Fig. 47, Strop on Rope or Bar—An endless strop or sling is made and wrapped around the bar as shown. The diagram shows how the ends of the sling are alternately passed through each other. The power is, of course, to be applied to the toggle. This is a most excellent method for getting a strong grip on a smooth bar or tube, such as a drill casing or tube jammed in a drill hole. It is suitable for hanging a block or tackle to a gin pole or a mast or rope. The sling should be made of relatively small rope, as it grips better. This arrangement is more powerful than a rolling hitch.

Fig. 48, Eye Splice—Open the rope as shown and pass the end B through to the back at D, and the end C through E; the center strand A will lie between the two strands x and y. A is now passed over x and under z; B over z and under y; C over y and under x. All three ends are now up, lying between two of the strands of the other part or standing of the rope. The process of over the next on the left end and then under the next strand but one is repeated as many times as the proposed load calls for.

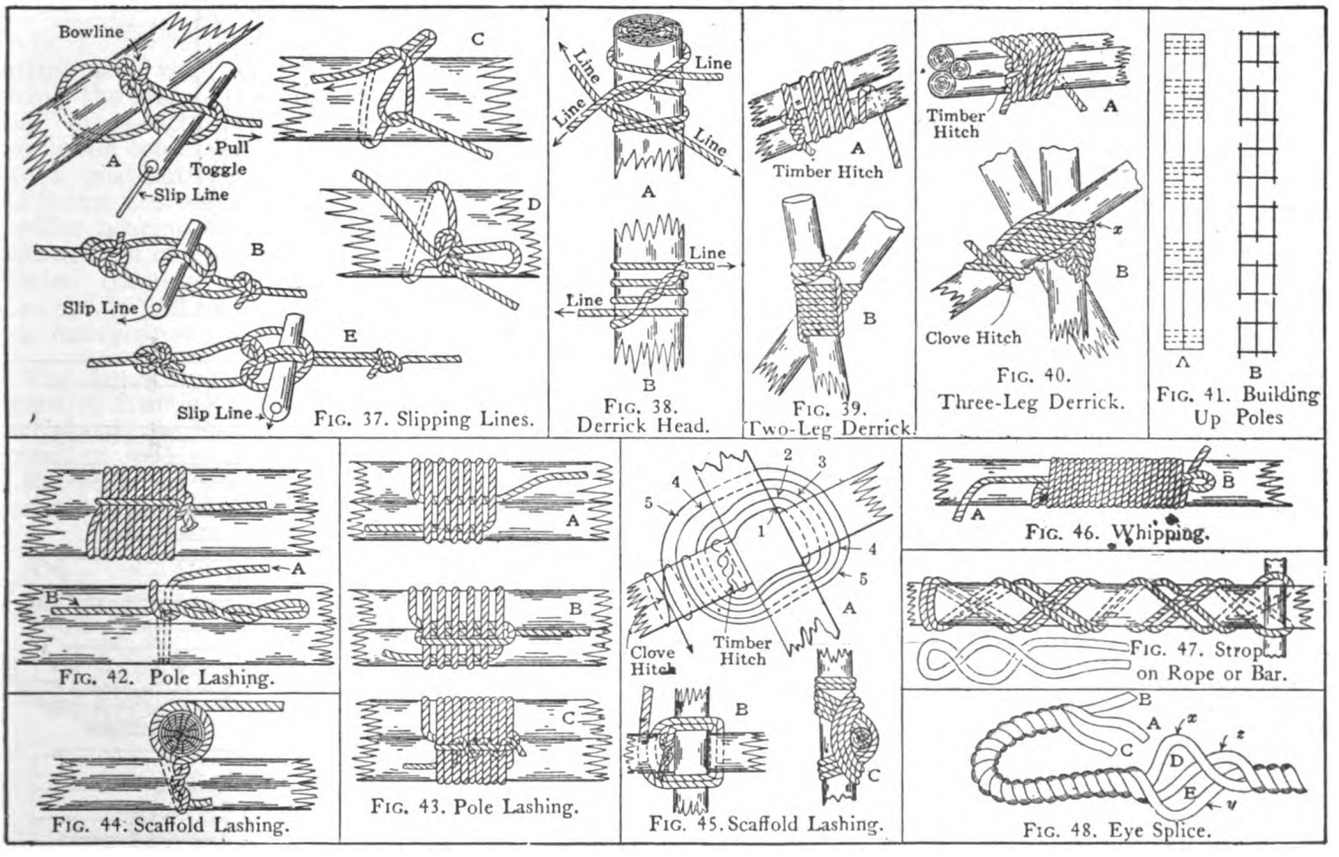

FIG. 37. Slipping Lines. FIG. 38. Derrick Head. FIG. 39. Two-Leg Derrick. FIG. 40. Three-Leg Derrick. FIG. 41. Building Up Poles

FIG. 42. Pole Lashing. FIG. 43. Pole Lashing. FIG. 44. Scaffold Lashing. FIG. 45. Scaffold Lashing. FIG. 46. Whipping. FIG. 47. Strop on Rope or Bar. FIG. 48. Eye Splice.

Slipping Lines, Eye Splice and Lashings for Derricks, Scaffolds and Poles

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METHOD OF FRAMING SQUARE SETS

Square sets were first used in the United States in 1860 by Philip Deidesheimer, at the Ophir Mine, Comstock Lode, Nevada. The method is often called the Nevada square-set system.

Post-Butting vs. Cap-Butting Sets

Practice is about equally divided between these types. Choice cannot be based on theoretical grounds alone, because: (a) unit pressures in square-set stopes generally exceed safe bearing values used for ordinary timber structures and hence there is considerable crushing of the joints; (b) direction or pressure is rarely parallel to caps or to posts, and its exact amount is never known; (c) distribution of stress in different members of a set under eccentric loading cannot be calculated, because joints are indeterminate and the members do not fit exactly.

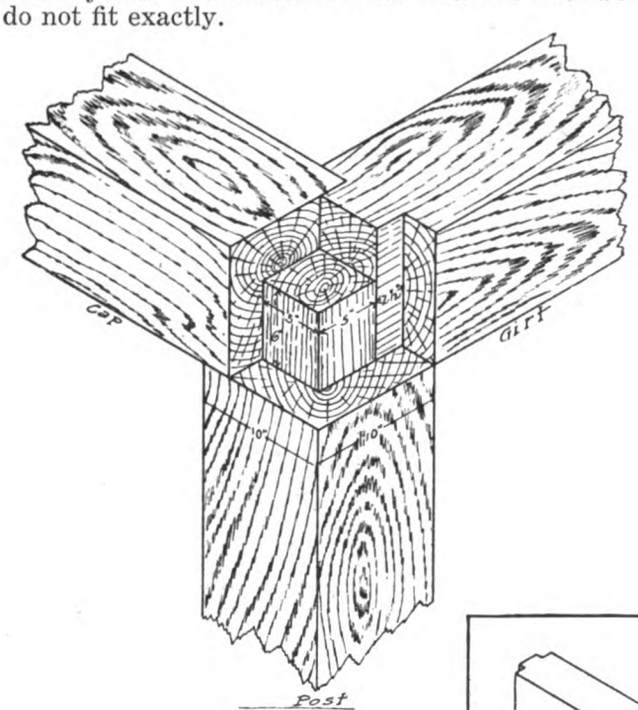

Fig. 1. High Ore Set.

Strength of timber under compression across the grain is from 10 to 20% of its compressive strength parallel to the grain. In framing post-butting sets, the area of the post tenons is made 12 to 44% of area of the joint; in cap-butting sets, the area of cap tenons is 10 to 66% of the area of the joint. Hence, under pressure within the limit of safe bearing values, square-set joints are always strongest in the direction in which the tenons butt. For such conditions of loading, post-butting sets should be used where the direction of maximum pressure is vertical; cap-butting sets, where the maximum pressure is lateral. Where pressures exceed safe bearing values, the joints are compressed. In cap-butting sets, ends of post bear entirely on wood in cross grain, and under vertical pressure the rate of compression is equal over the whole area of joint. In post-butting sets, under heavy vertical pressure, the post tenons or horns must fail before the cross-grain wood in caps and girts can aid in transmitting pressure to the post. As the rate of compression is not the same in all parts of a joint, settlement in a stope is often irregular. The settlement is greater and more irregular in post-butting than in cap-butting sets, and more auxiliary timbers are needed in the former to keep the

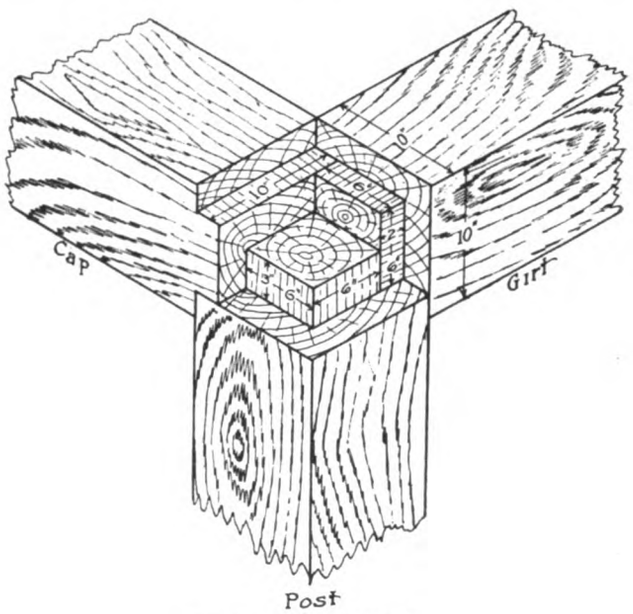

Fig. 2. Burlingame Set.

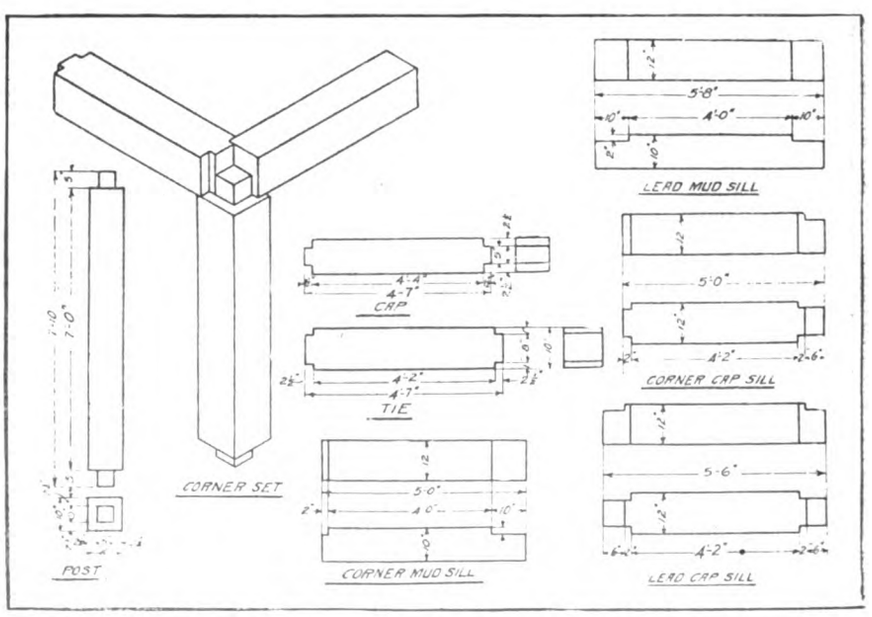

Fig. 3. Copper Queen Set.

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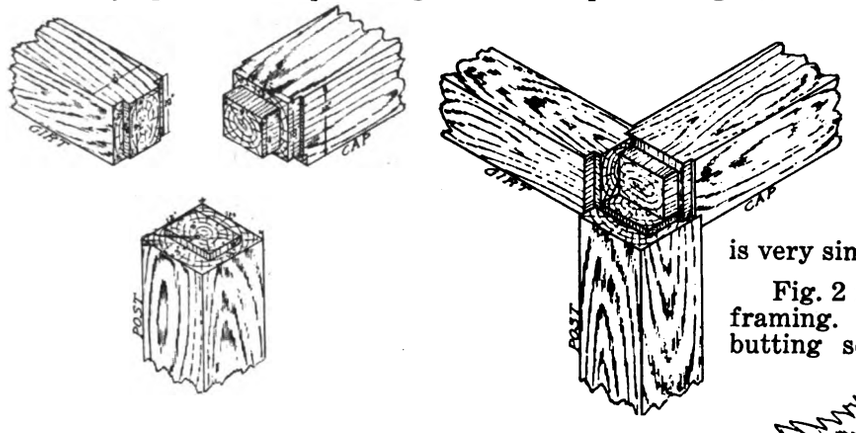
floors level. For this reason, many engineers prefer cap-butting sets for heavy vertical pressure, and practice is almost uniform in using them for heavy lateral pressure, also, though arguments like the above indicate the superiority of post-butted sets. But, in heavy ground, filling follows mining closely and takes most of the lateral pressure; the smaller and more uniform rate of vertical settlement of cap-butting is a strong argument for their use in such ground.

Square-sets may also fail by "jack-knifing"; posts swing out of line and eventually a girt or cap drops, allowing adjacent sets to collapse. Hence, wide seats for girts and caps are desirable, and are commonly given in cap-butting sets. In post-butting sets, wide seats are obtainable only by reducing the size of the post horn. Long horns of small cross-section are always objectionable, as they break too easily. With timbers over 10 by 10 inches, post-butting sets with adequate shoulders and horns are readily framed. Sometimes to give a wider bearing for either girt or cap, horns on posts are not of square section; they require a complicated framing machine. Note that girts are more apt to pull away from their seats under light than heavy pressure.



RICHMOND FRAMING

Fig. 4.

The following are some empirical rules with regard to framing details: (a) length of the post horn should be less than its least cross-sectional dimension; (b) girts and caps should have a seat on the post not less than 2 inches wide; a wider shoulder is desirable. Simple framing is best, especially for hand framing. Post-butting sets are generally simpler and cheaper to frame than cap-butting sets, but the difference is small when framing machines are used. Complicated joints resist distortion better because of the numerous shoulders, but this advantage is doubtful, as corners are points of weakness at which crushing begins, and such joints are difficult to assemble if the timbers have been even slightly crushed. Symmetrical framing is best. It costs less to place timbers when the posts can be set either end up; caps and girts also should be framed so that either of two opposite faces may be placed upwards.

Fig. 1 shows the method of framing used at the High Ore mine at Butte. It is a simple joint of the post-butting type and lends itself readily to being framed by hand. It is unsymmetrical, with a 6-inch horn at the top and 4-inch at bottom. This secures a shallower mortise at top of the set, which is easier to clean out and allows "flirting" the post, if sets have swung slightly out of line. This method is very similar to the original Deidesheimer set.

Fig. 2 represents the Burlingame method of framing. It is one of the best of the post-butting sets, the caps and the girts being dapped down so as to catch the body of the posts, so that any side shock coming on the post is not thrown entirely upon the horn.

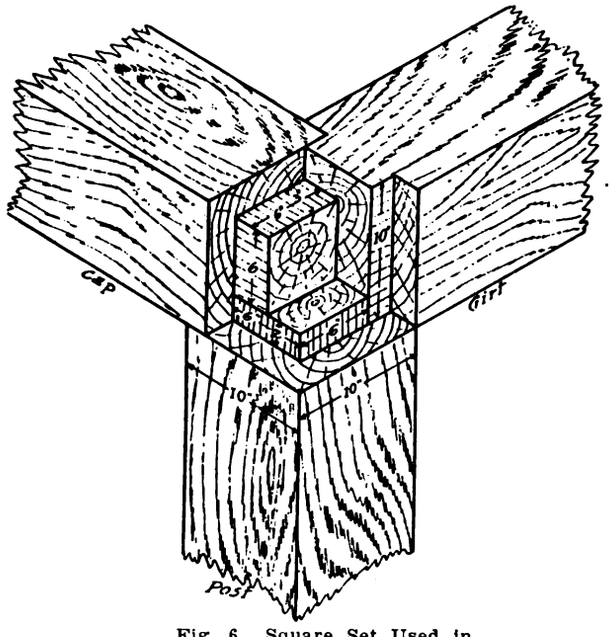


Fig. 6. Square Set Used in Anaconda Group.

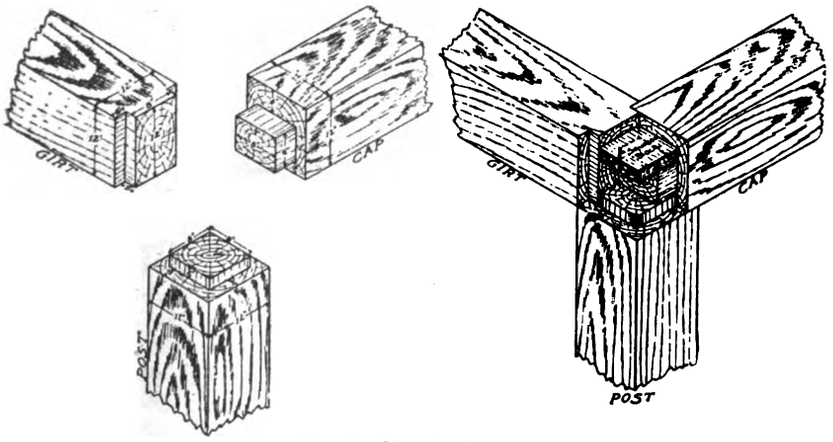


Fig. 5. Eureka System.

Fig. 3 gives the details of the set used at the Copper Queen mine, Bisbee. It is a post-butting set. This is very similar to the High Ore set, the difference being that the cap and not the girt is dapped. In the larger sized timbers at this mine both girt and cap are commonly dapped. Fig. 3 shows details of pieces for the whole corner set.

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Fig. 4 represents the framing used at the Richmond mine, at Eureka, Nevada, which, as can be seen, is rather complex. Owing to its being rather

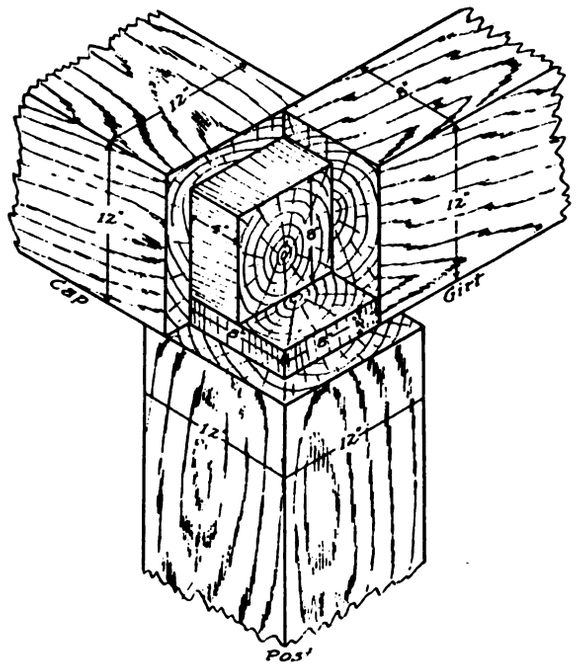


Fig. 7. Stope Set at Leonard.

complicated it was more expensive to frame, although, owing to the more shoulders that there were, it resisted distortion better than less simple types. It is characterized by a dapping of both the girt and the cap, so that they come down on the full face of the post for a little ways. It is a post-butting type. The reason for a rather complicated system at this mine was the heavy ground encountered with great side pressure. At that time the stopes were kept open by the timber alone without filling.

Fig. 5 embodies a principle in timbering not ordinarily appreciated. This is the use of the "squeeze piece" to keep the timbers from being damaged by the unequal loading they are apt to receive when the weight first comes on them. This is an advisable method to use where very heavy ground is encountered, especially with great side weight, to gradually take up the creep. The most

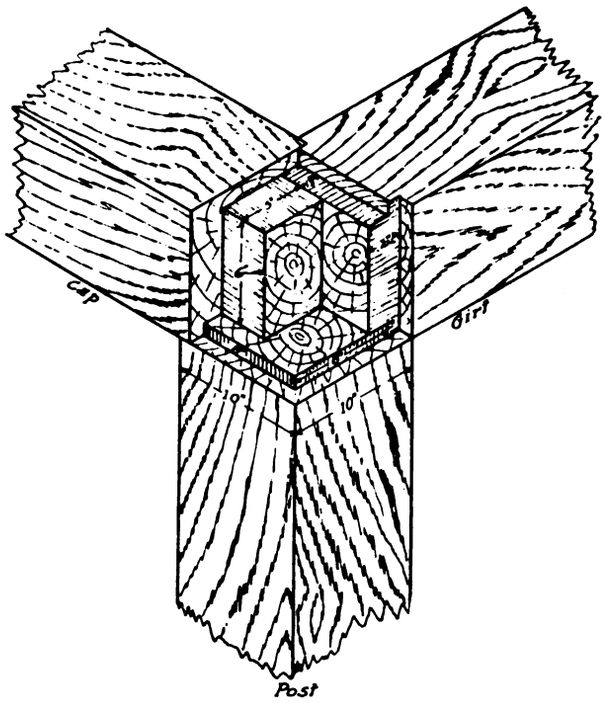
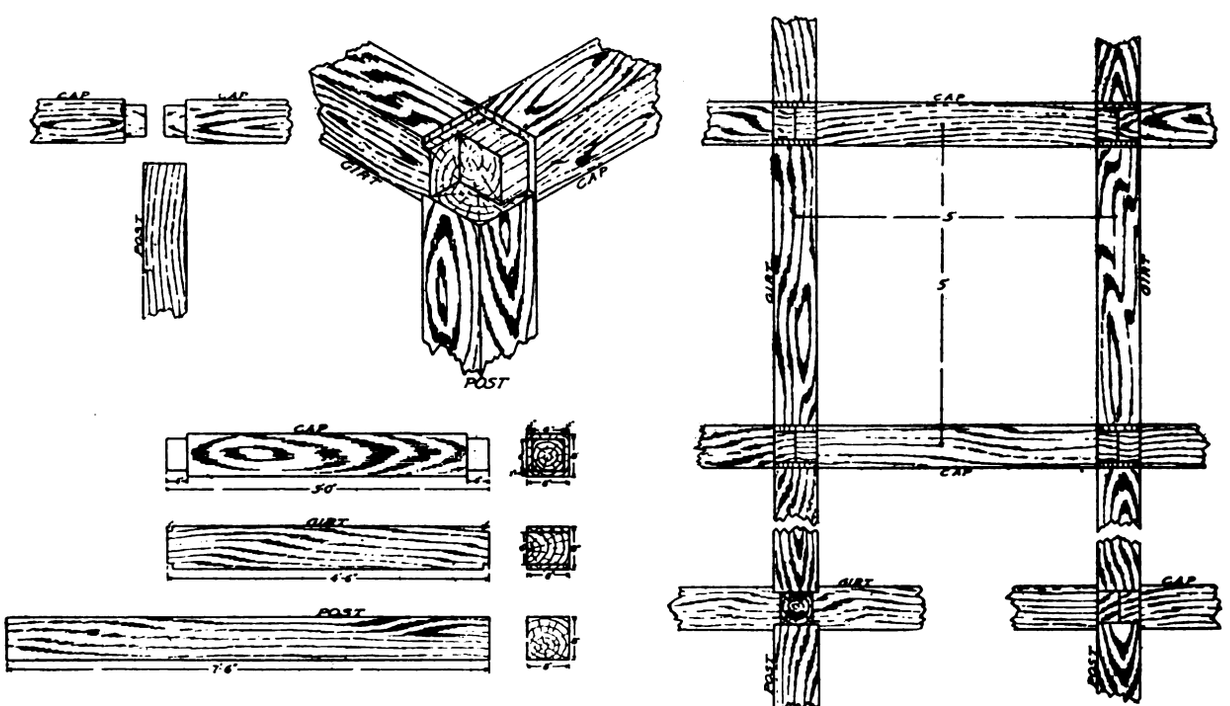


Fig. 8. Syndicate Group.

serious objection is that unequal settling is likely to give uneven floors and to make the connecting up of break-throughs awkward. It is a cap-butting form, known as the Eureka type.



ESPERANZA MINE

Fig. 10.

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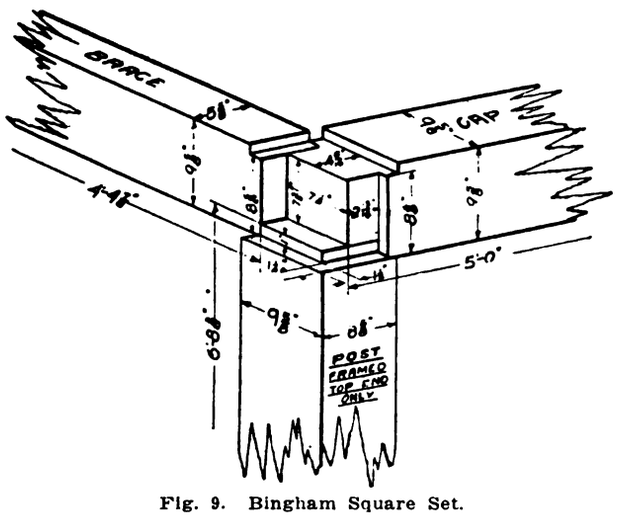

Fig. 9. Bingham Square Set.

Figs. 6 and 7 are two forms used at the Anaconda and Leonard mines, respectively. Both are cap-butting forms similar in a general way to the Eureka type. In the Anaconda set the girt as well as the cap and post is framed. In the Leonard set, the girt is not framed but it as well as the cap rests fully on the post. This is regarded by many as the best framing for square timber. It is cheap, simple and retains full strength of timber for both lateral and vertical pressure.

Fig. 8 is another Butte form used in the Syndicate group. Also a cap-butting type. The girt is framed so as to gain over on the horn of post just enough as does the cap. The caps, though, have horns long enough to butt. This form provides wider supports for the horizontal members, which is an advantage especially with small timbers, but weakens the cap horn. Unsymmetrical cap and girt horns increase framing cost and difficulty of placing timbers.

Fig. 9 is another cap-butting form. In this type the bottom end of the post is not framed, but sets in the depressions made by stepping back the top shoulder of the caps. This gives a shallow mortise with open corners, making it easy to clean out. This form is used at Bingham, Utah, and Leadville, Colorado.

Fig. 10 is the form used at the Esperanza mine, El Oro, Mexico. It will be noted that the post is unframed with caps butted. Since the post is unframed and the members all symmetrical, the set is cheap to frame and to erect, and is good for light pressures. It is an especially good type for hand framing where light timbers can be used.

FRAMING ROUND TIMBERS

The framing of square sets out of round timbers has only become common of late years. They were not used formerly because of the difficulty of framing good joints by hand.

Round timber is cheaper, has lower freight rates, and is stronger per square inch, because the outer fibres are uncut; step-down framing, similar to Fig. 17 gives an efficient joint and removes the greatest drawback to its use. But, round timber is harder to handle and align than square; caps must be slabbed to receive flooring, though cost of slabbing may be offset by value of slabs, if used for lagging. Reinforcement of round-timber sets is

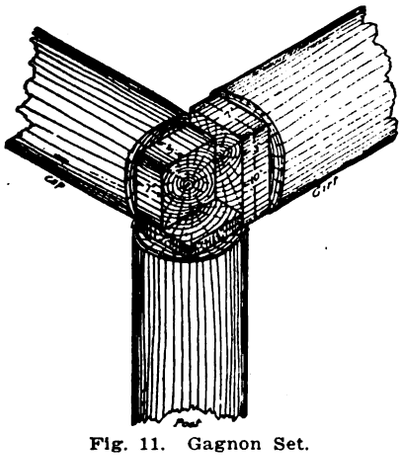

Fig. 11. Gagnon Set.

difficult and expensive. Use of round timber is increasing, especially in stopes where filling closely follows mining. Sound fallen timber, and some trees of poor grade, or too small to go to the sawmill, often furnish adequate square-set timbers at reduced cost.

Square timber is best for sills. In some round-timber stopes, square timber is used for levels, manways and chutes, to cheapen work of reinforcement. Square timber is preferred for chute sets; it provides a flat space for spiking lining and lasts longer in heavy ground than slabbed round timber.

There are shown herewith details of some of the different methods of framing round timbers.

The simplest joint is made by first squaring the ends of the timbers for a sufficient length to avoid interference of their cylindrical surfaces at the joint, which is then framed as with square timber. This saves the cost of squaring the whole log, an important item in hand work. The disadvantages are: the joint utilizes a maximum of only 60% of the cross section of the timber, and round timber weighs at least 40% more than square of equal joint strength. Figs. 11 and 12 show simple framings, open to the objections stated. They also provide a poor seat for the bottom of the post. Both are used at the Clark mines at Butte.

Fig. 13 shows a combination of square and round timbers. The posts are butted and are round timbers, as are the girts. The caps are made of square timbers. Practically the whole strength of the post is obtained, which is the most important thing in framing a square set; the timbers are easily reinforced, and easily stood, while all framings meet in square corners and butt with square shoulders against one another. It also provides a smoother shoveling floor.

Figs. 14, 15 and 16 show three different forms of bevel framing of round timbers. Fig. 18 represents a form used at the Chillagoe mines in Australia. It will be noticed that the caps and girts are both alike and meet in 45 degree bevels. There is little to recommend the framing except that it is

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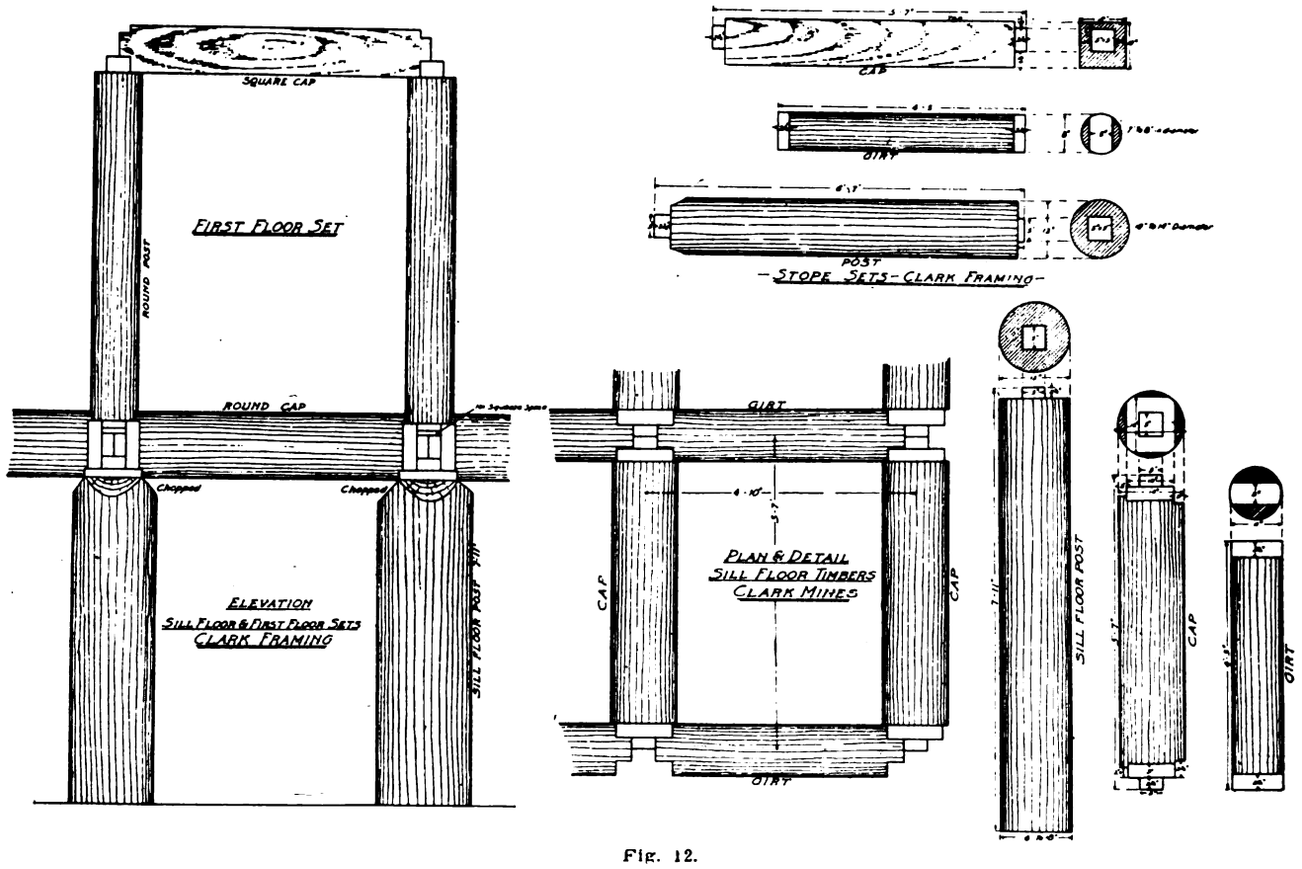

Fig. 12.

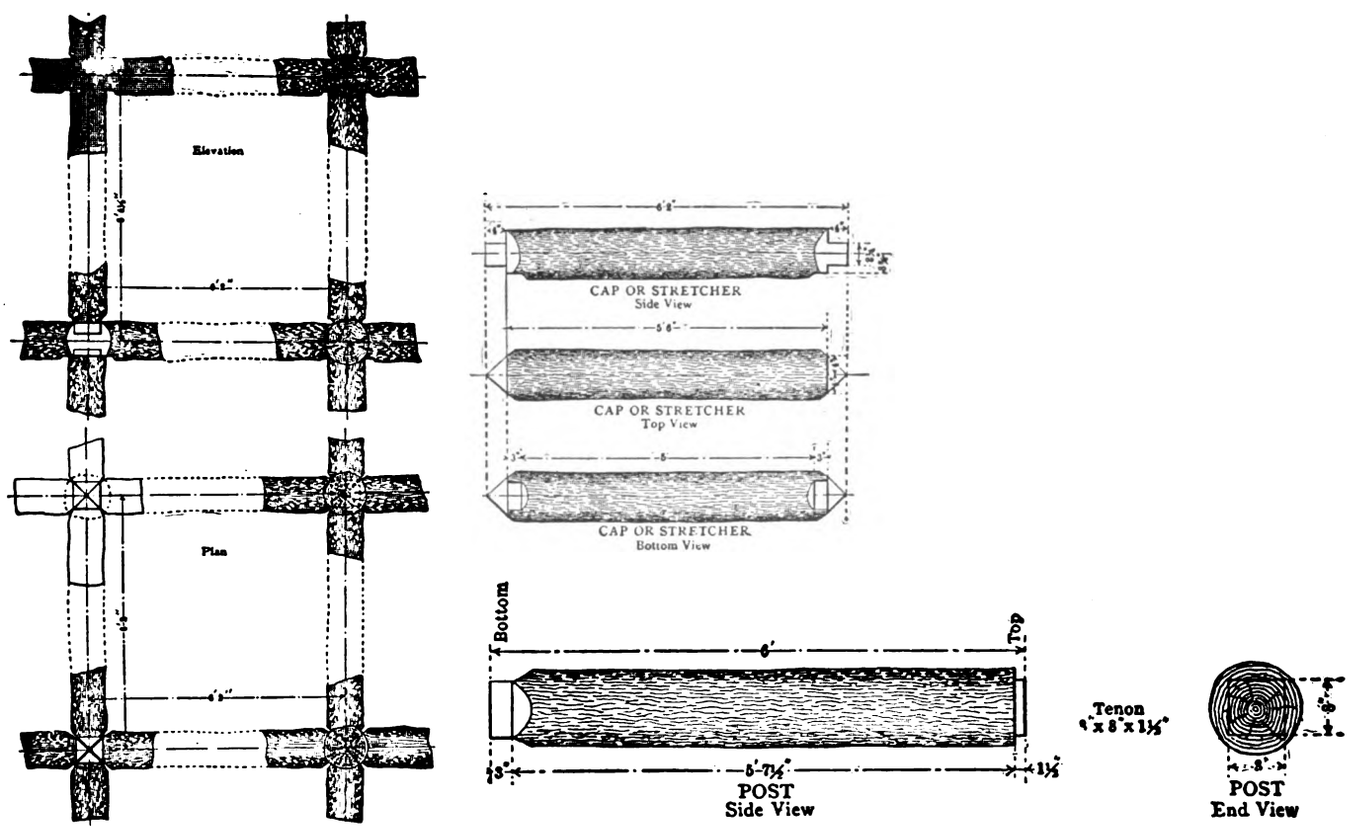

Fig. 14. Australian Round Timber Set.

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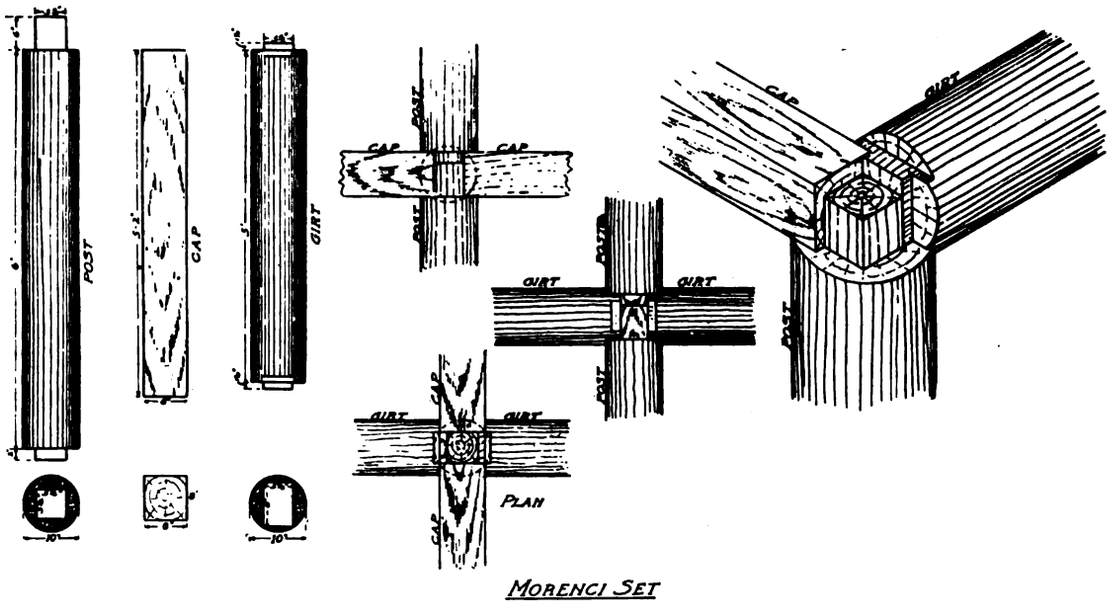

MORENCI SET

Fig 13.

simple and answered the purpose for which it was designed, hand framing of round logs into square sets. Fig. 15 is another form first used by Brunton

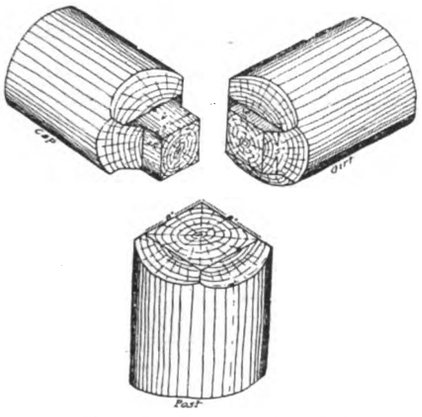

Fig. 15. Brunton Bevel Set.

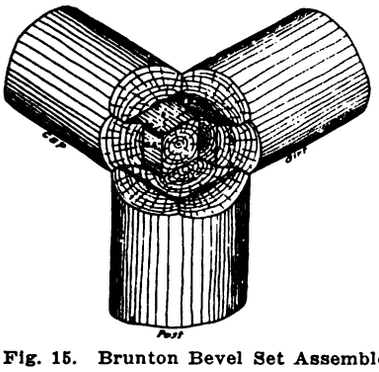

Fig. 15. Brunton Bevel Set Assembled.

at Butte, but abandoned in favor of style shown in Fig. 17. Owing to the beveling of the posts it was impossible to block these sets from the side until they had been blocked down from the top, so as to prevent the girts and caps from riding the post as blocking pressure was brought on them. Fig. 16 illustrates a form where the shoulders of the post are square and the rest are beveled. It is used in the Mesabi iron district. This framing is a good one, as it provides for strong resistance of the top weight. A 1-inch squeeze space is left between the post tenons, giving a cushioning effect to prevent caps from splitting. It may be blocked in any direction, with some of the members missing. It resists pressure well until the set begins to distort, when

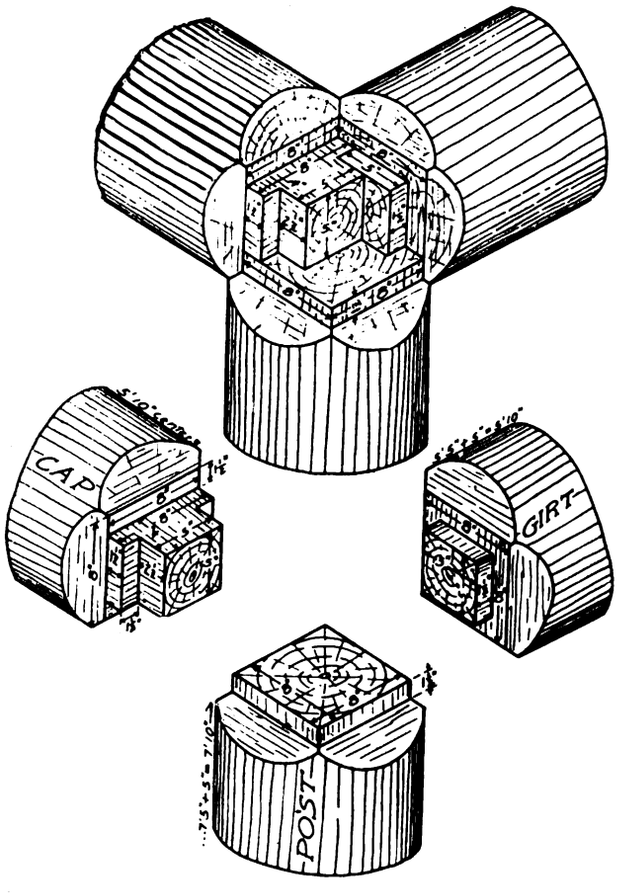

Fig. 17. Brunton Combination Bevel and Square Framing.

the bevel joining of the caps and girts will cause the distortion to magnify rapidly as the weight continues to come on the timbers.

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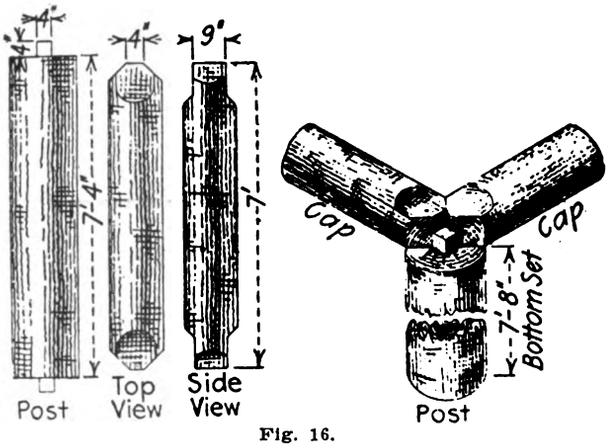
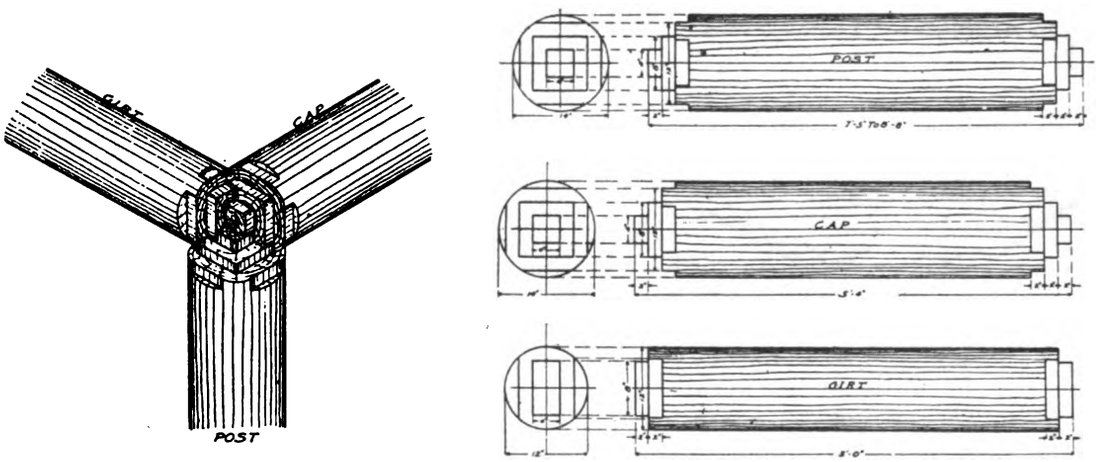


Fig. 16.

Fig. 17 is a later form devised by Brunton to overcome the weaknesses of his former set. It is a combination bevel-and-square framing. It is simply a modification of the Richmond framing (Fig. 4), with bevels added to step down the stick to framing dimensions. It is a fairly good framing and the best of the bevel framings for round timbers. It is easily framed except the cap. This form is much used in the Butte district.

Fig. 18 represents a later type of framing called the Amalgamated. In this system all the shoulders are square, and in order to approximate as closely as possible to full butting of the timber, it is necessary to use a series of these stepping-down shoulders. This is a cap-butting joint. The joint requires a large number of cuts, but is rather simple to cut, as special framers are used. To get the best results from this set it is necessary that the different members of any one set be of about the same size.

In reinforcing of square sets made from round timbers, the only feasible way of doing this is by the use of bulkheads. Posts are hard to secure and means the cutting away of the surface to get bearing surface, which weakens the timber and seldom makes a good joint.



AMALGAMATED STEP-DOWN FRAMING—

Fig. 18.

Compiled from "Square-Set Timbering" by C. T. Rice in Mining and Engineering World, 1912 and 1913.

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SHAFT TIMBERING IN THE BUTTE DISTRICT

The placing of the collar set is the first thing to be done in starting a shaft. Its height above the ground is determined by the amount of room available for the dumping of waste rock from the sinking operations. In a level place it is generally raised about 20 ft. The wall plates of the collar set are usually made 10 ft. longer than the shaft set, projecting 5 ft. at each end. This set bears the weight of the shaft sets below and usually of the gallows frame. Posts resting on blocks are placed under each end, and diagonal braces are then placed around the shaft to carry part of the weight and prevent the set from moving. Figs. 1 and 2 show the collar set of a two-compartment shaft, with diagonal braces and posts.

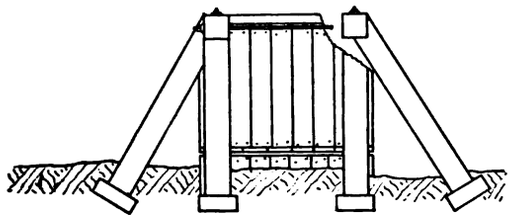

Fig. 1. End View.

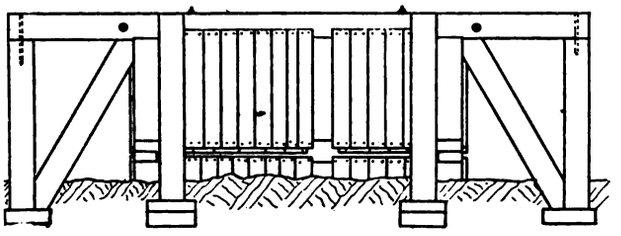

Fig. 2. Longitudinal View.

The sizes of guides vary greatly in the district. At first 4 by 6 in. guides were used almost universally, but lately the size has been increased to 4 by 9 in. and 5 by 9 in., held in place with $\frac{7}{8}$ by 8 in. or $\frac{7}{8}$ by 9 in. lag screws. The larger size guide can stand heavier loads and greater shocks, and two lag screws are used in each timber; the holes, two in number, are placed diagonally across in the other direction, giving fresh timber for the screws to hold to.

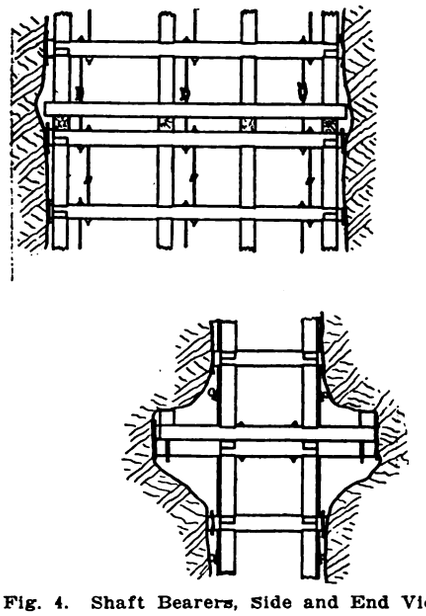

Fig. 4. Shaft Bearers, Side and End View.

Guide posts are vertical posts running behind the guides to give them more support. They are framed into the centers and end plate of the shaft. When used they are carried in the main hoisting compartment, but not in the pump compartment. They are the same width as the centers, and usually 12 in. in the other direction.

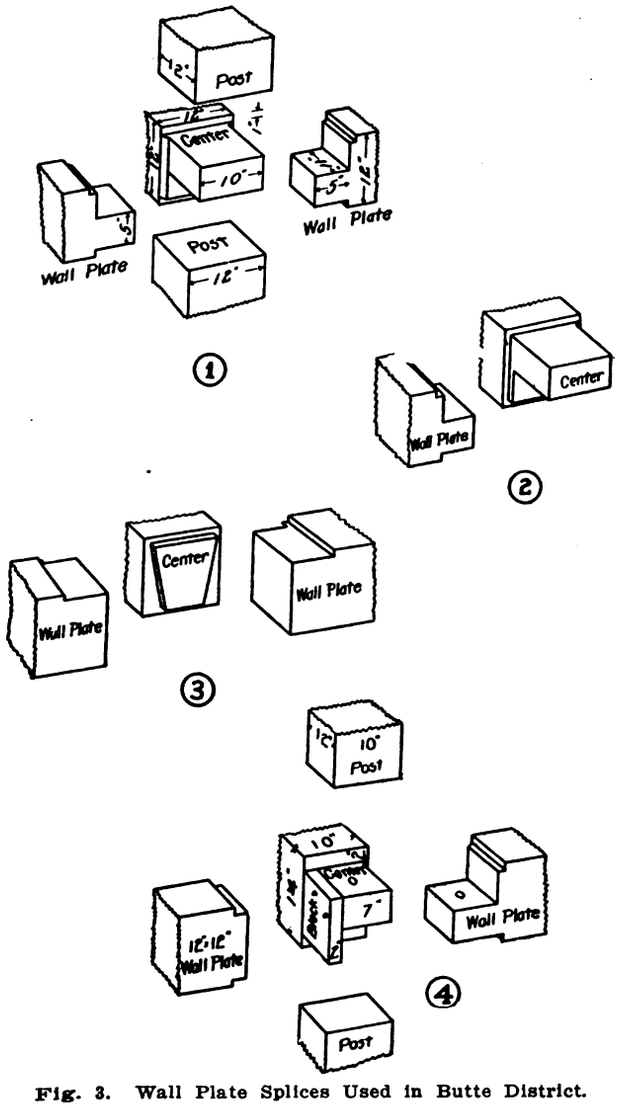

Fig. 3. Wall Plate Splices Used in Butte District.

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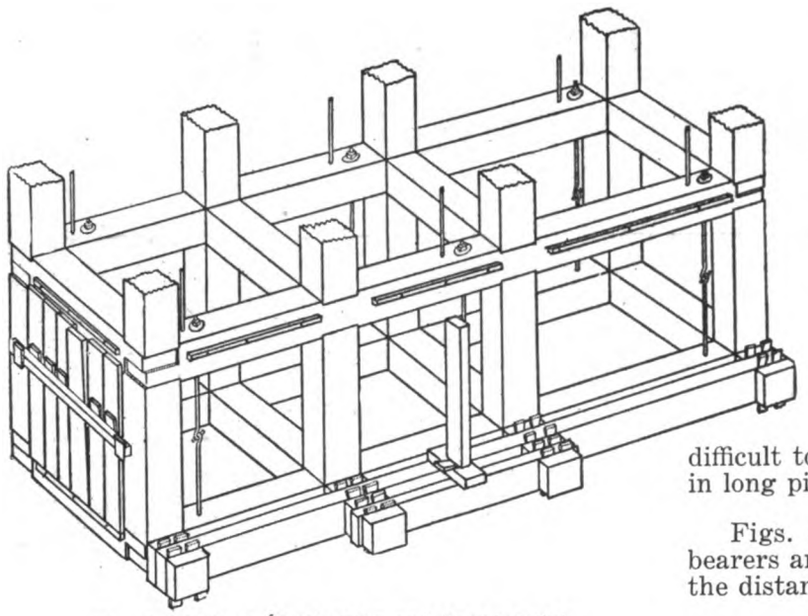
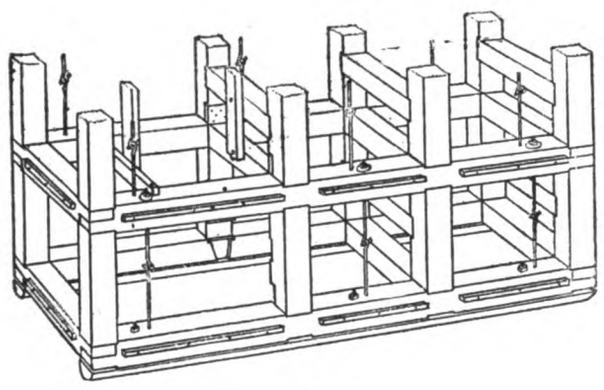


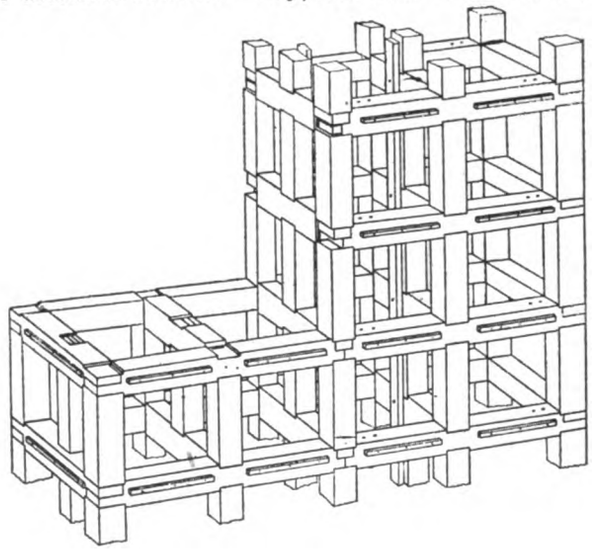
Fig. 5. Method of Blocking and Lagging Set.

Guide girts are those running horizontally between the posts and equidistant between the centers of the shaft, giving support to the guide and also helping to take the side weight off the shaft.

Wallplates are quite commonly spliced in this district. Fig. 3 shows four forms that are used. The first is most common and the best. The fourth method is not as strong but is advantageous in sinking a small shaft that may be later enlarged. The reason for using a splice is the difficulty of getting sufficiently long pieces of timber of good grade and in heavy ground it is often difficult to keep the shaft open long enough to put in long pieces.

Figs. 4 and 5 show the method of placing bearers and of placing lagging and blocking. When the distance is small—say, not over 1 ft.—a single





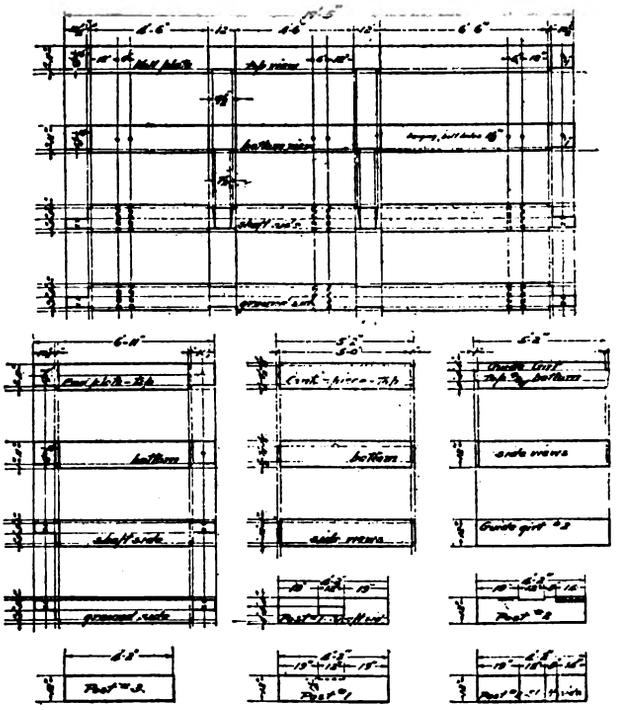


Fig. 6. Complete Shaft Set with Framing Details for Three-Compartment Shaft.

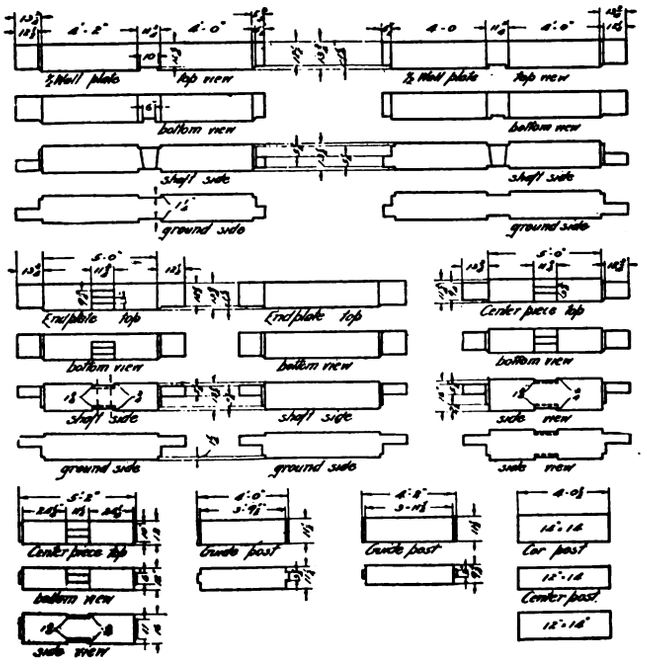


Fig. 7. Isometric and Framing Details of Leonard Four-Compartment Shaft.

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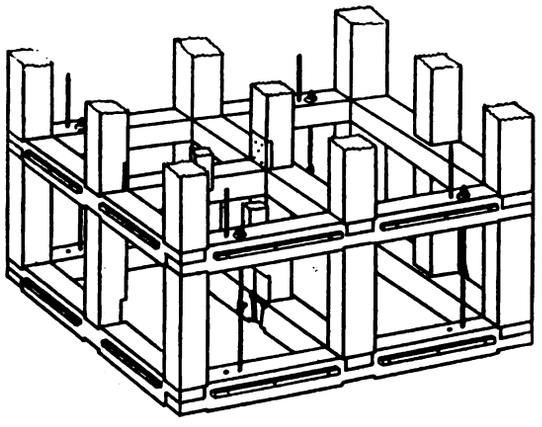
block is placed between the set and the wall, the wedging being done between the block and the wall. When, however, the ground breaks back farther, a block of about 5 in. thickness is placed back of the center and toe-nailed. A stringer the length of the shaft is then placed along the side and nailed to the blocks. Blocks are again placed, and then stringers as needed. The wedging is then done between the blocks and stringers. The wedges should be driven from below as well as from above.

Fig. 6 shows isometric of complete shaft set for three-compartment shaft, also framing details of the set. Two compartments are for hoisting and one for ladder-ways, etc. Timbers used are 12 by 12 in. Guide girts are used in this case. This is the usual type of shaft used in the Butte district.



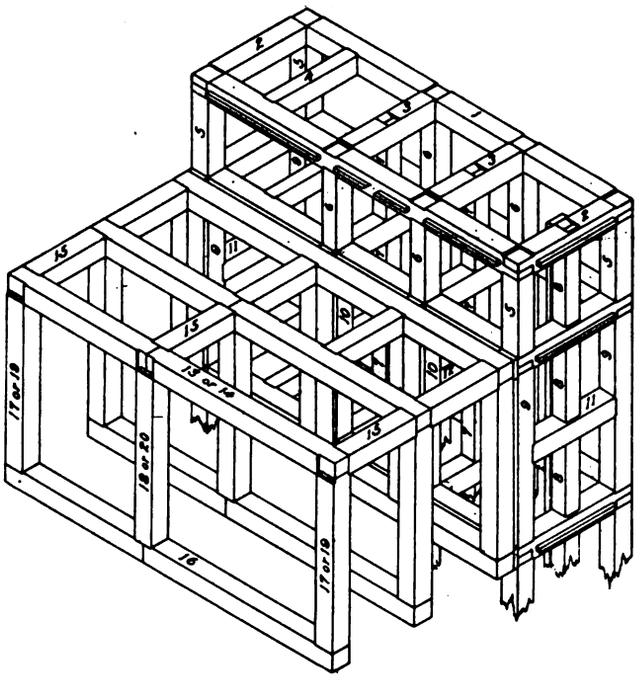


Fig. 10. Isometric of Shaft and Station Sets.

Fig. 7 shows isometric and framing details of the Leonard four-compartment shaft. In this form two compartments are sinking and two are raising. 14 by 14 in. wall plates are used. Vertical guide posts are used in this type.

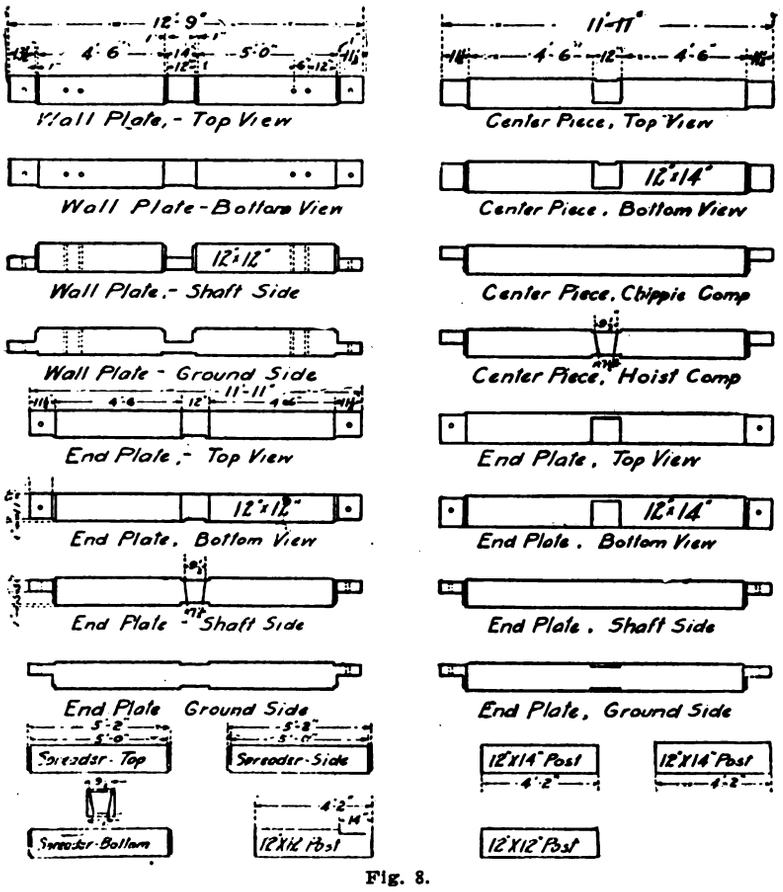


Fig. 8.

Fig. 8 shows an almost square shaft with three compartments. The two smaller ones are for the hoisting of ore and rock, while the third is for the handling of supplies, especially timber. A small part of this compartment is set apart for piping, wires, etc. This larger compartment is a great advantage in large mines which use the square set method, for the amount of timber necessary is very large and in some cases delays the hoisting of the ore in the smaller shafts. The disadvantage of this type of shaft timbering is that it is more difficult to keep open in heavy ground.

Fig. 9 shows the framing of a three-compartment rectangular shaft using one-piece wall plates. This is the form used in the Rarus and Tramway mines. The ground in this section of the district is heavy and this form has been found to work well.

Fig. 10 shows the type of station set used in the Butte district for a three-compartment shaft. In this set provision is made so that settlement of the station timbers will not tend to pull the shaft timbers out of alinement. The shaft timbers are securely braced, how-

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ever, against the station set. The methods of doing this differs greatly in the camp. The first line of station sets, it will be noticed, are but a few inches away from the front of the shaft sets. Due to the necessity of using long vertical stringers at a shaft station and due to the large opening of the station itself, this is likely to be a weak point, so that it is quite common to use jacket or overcoat sets at these points. Fig. 11 shows in plan the general arrangement of the form used at the Leonard mine.

Fig. 12 shows the details of framing of one form of overcoat set used in the district. This set, which is somewhat more costly than other forms, is less used, but is the best because it allows the lower jacket sets to stand up under the down weight that may in time be thrown on them by the upper sets that are in bad ground.

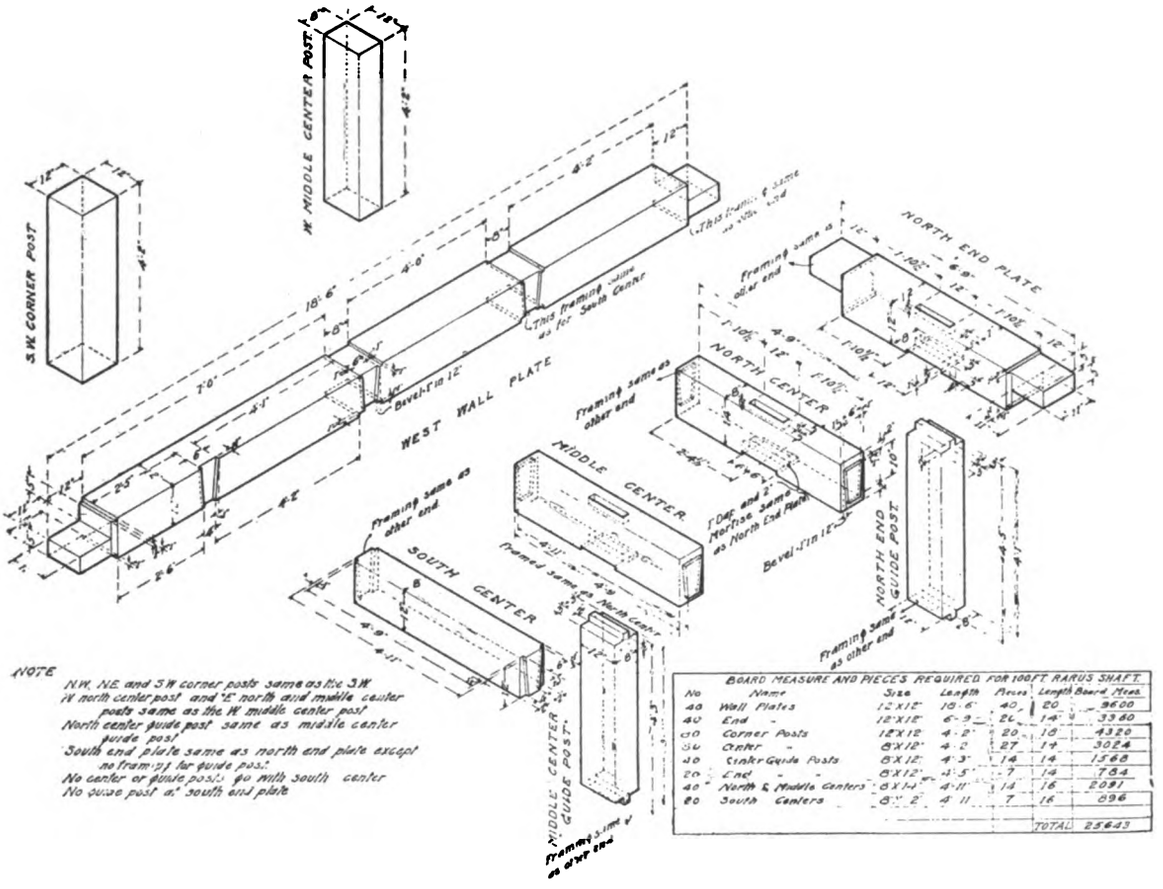

Fig. 9. Framing Details of Rarus Shaft Using One-Piece Wall Plate.

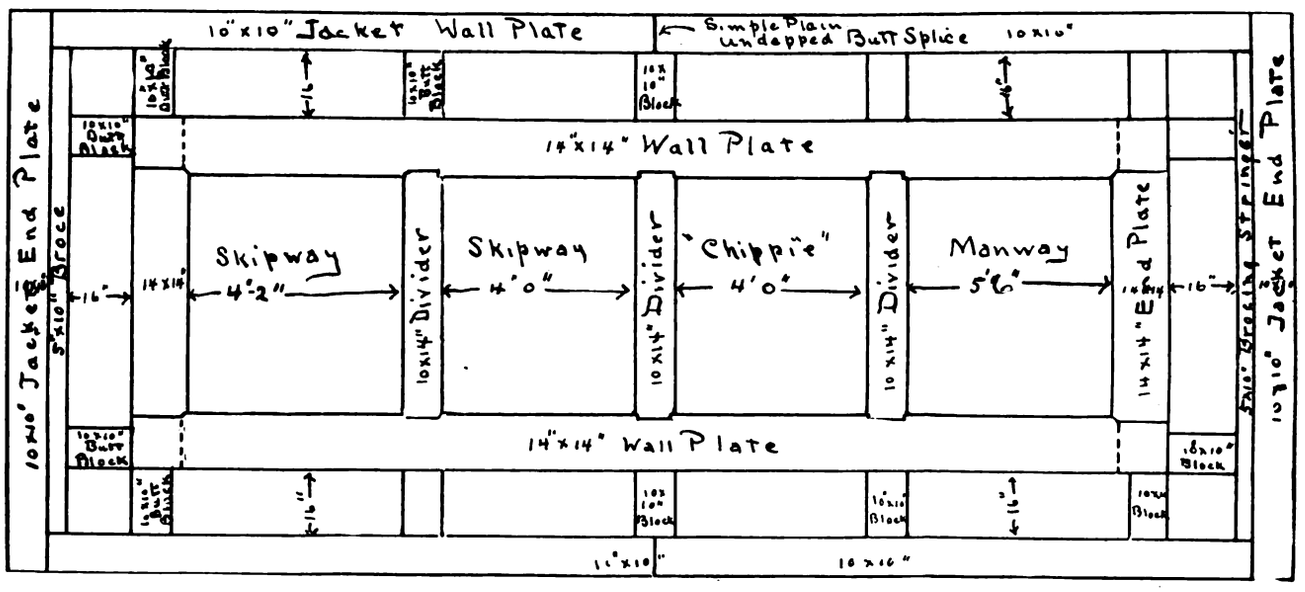

Fig. 11. Leonard Jacket Set.

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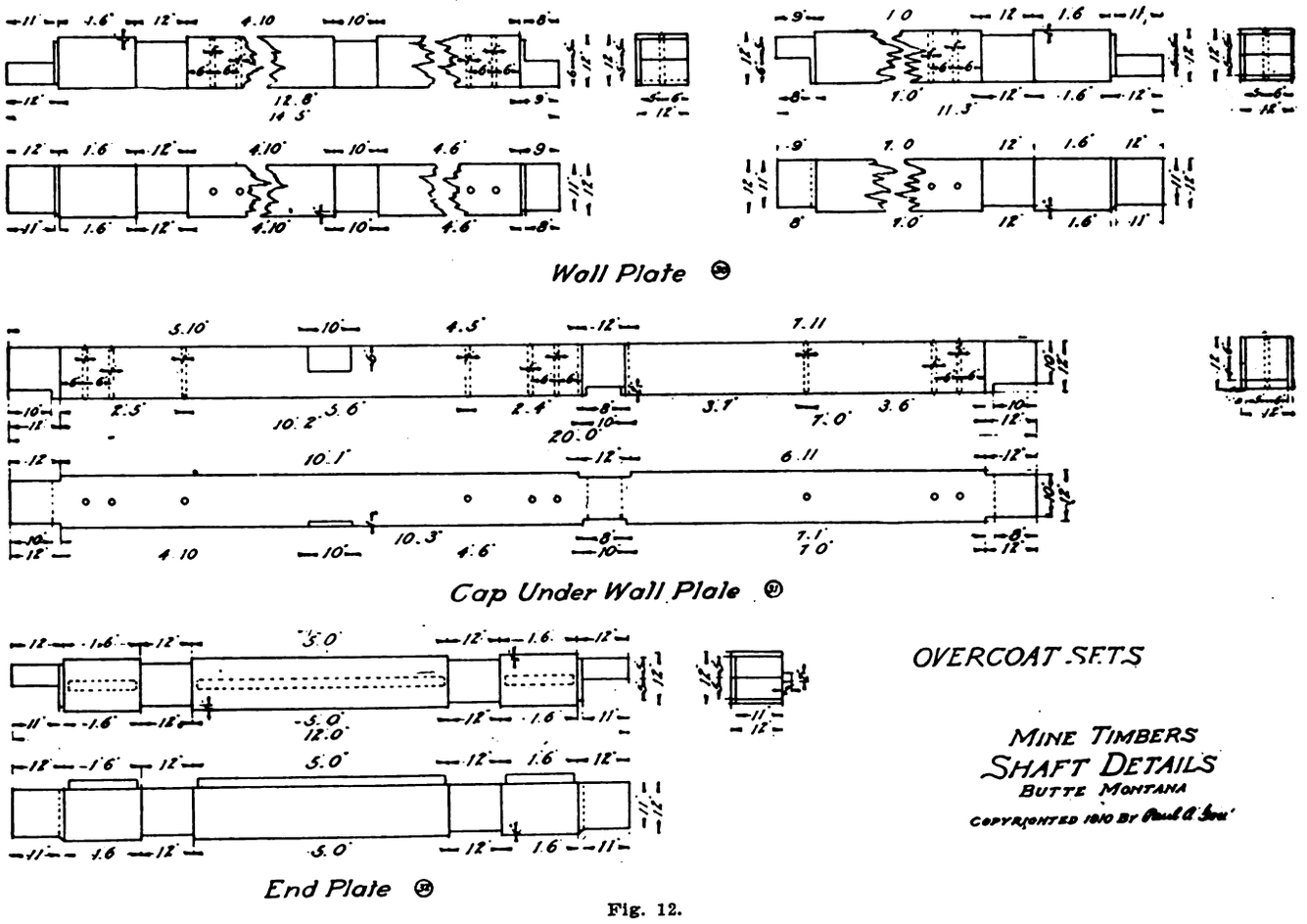

Fig. 12.

Compiled from "Shaft-Sinking Methods of Butte" by N. B. Braly, Trans. A. I. M. E., 1913, and "Shaft Timbering in the Butte Copper Mines" by C. T. Rice, Mining and Engineering World, 1913.

MISCELLANEOUS BUILDING DATA

FULLER'S RULE FOR CONCRETE QUANTITIES

The simplest rule for determining the quantities of materials for a cubic yard of concrete is one devised by William B. Fuller. It is expressed in words as follows:

Divide 11 by the sum of the parts of all the ingredients and the quotient will be the number of barrels of portland cement required for one cubic yard of concrete. The number of barrels of cement thus found, multiplied respectively by the "parts" of sand and stone, will give the number of barrels of each required for one cubic yard of concrete and multiplying these values by 3.8 (the number of cubic feet in a barrel), and dividing by 27 (the number of cubic feet in a cubic yard), will give the quantities of sand and stone, in fractions of a cubic yard, needed for one cubic yard of concrete.

To express this rule in shape of a formula:

Let C = Number parts cement;
S = Number parts of sand;
G = Number parts of gravel or stone.

Then $\frac{11}{C \times G \times S} = P$ = number bbl. portland cement required for cu. yd. of concrete.

$\frac{P \times S \times 3.8}{27}$ = number of cu. yd. of sand required for 1 cu. yd. of concrete.

$\frac{P \times G \times 3.8}{27}$ = number of cu. yd. of stone or gravel required for 1 cu. yd. of concrete.

The accompanying table. is made up from Fuller's rule and represents fair averages of all classes of material.

MATERIALS FOR ONE CUBIC YARD OF CONCRETE

Proportions	Cement Bbls.	Sand Cu. Yd.	Gravel or Stone Cu. Yd.
1:1½:3	2.00	0.42	0.84
1:2:4	1.57	0.44	0.88
1:2½:5	1.29	0.45	0.91
1:3:6	1.10	0.46	0.93
1:4:8	0.85	0.48	0.96

If the coarse material is broken stone screened to uniform size, it will contain less solid matter in a given volume than an average stone, and about 5% must be added to the quantities of all the materials. If the coarse material contains a large variety of sizes so as to be quite dense, about 5% may be deducted from all of the quantities.

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ORE CHUTE TIMBERING

Figs. 1 and 2 show the standard chute and standard gate use at the North Butte mine at Butte. The two wooden doors control most conveniently the flow of rock, but an iron door is also placed at the mouth of the chute to facilitate shutting it off at any time without having runs of rock.

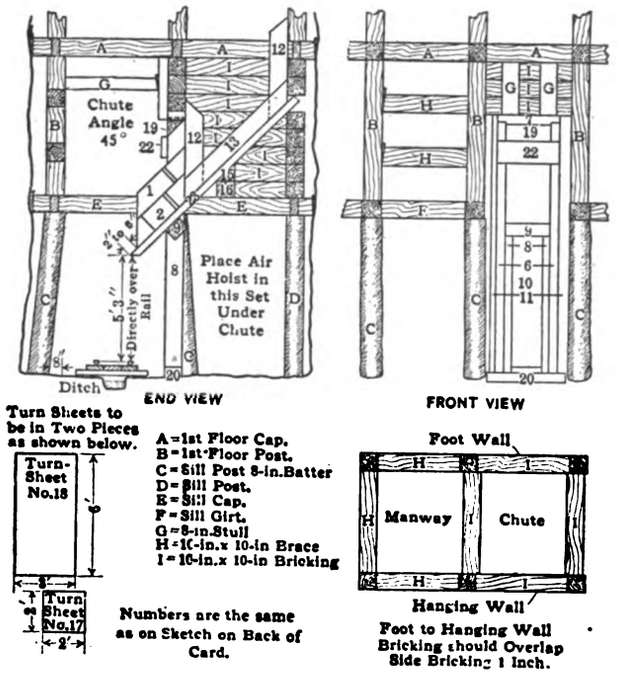

Fig. 1. Face of Card Shown in Fig. 2.

Standard Girt Chute

Instructions: In starting to put in a chute, see that the ends of the bottom plank are directly over the near rail and 5 ft. 3 in. above it. The center of the standard should line with the center of the post at the top and be exactly plumb, regardless of the batter on the sill posts. Bottom plank to be on a 45 degree slope; chute jaws 2 to 6 in. above the chute plank. In heavy ground make end of chute 5 ft. 8 in. above rail.

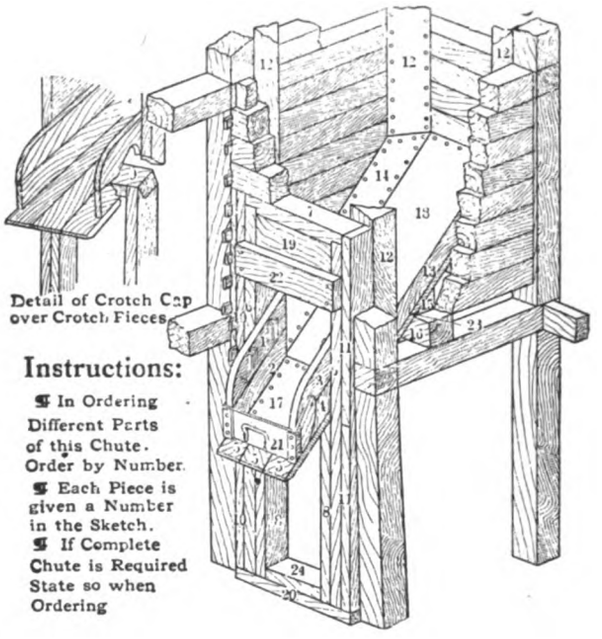

Fig. 2. With Table Given Below Makes Up Back of Card Shown in Fig. 1.

	Piece	No. Required	Dimension
1	Left chute jaw.....	1	3"x10"x3'10"
2	Left chute jaw.....	1	3"x12"x3'10"
3	Right chute jaw.....	1	3"x10"x3'10"
4	Right chute jaw.....	1	3"x12"x3'10"
5	Bottom plank	3	4"x10"x10'10"
6	Standards	2	5"x10"x12'2"
7	Standard cap	1	5"x10"x3'
8	Crotch pieces	2	4"x10"x6'6"
9	Crotch cap	1	6"x10"x2'2"
10	Left filling piece.....	2	4"x10"x6'
11	Right filling piece.....	2	4"x10"x6'
12	Corner vertical piece....	4	10"x10"x5'—45%
13	Right cor. bottom piece..	1	10"x10"x6'8"
14	Left cor. bottom piece...	1	10"x10"x6'8"
15	Bottom brace	1	10"x10"x3'6"
16	Bottom brace	1	10"x10"x5'10"
17	Bottom turn sheet.....	1	2'x2'
18	Bottom turn sheet.....	1	6'x3'
18	Filling piece	1	10"x10"x2'2"
20	Sill piece	1	4"x10"x3'
21	Chute door	1	.....
22	Front piece	1	4"x10"x3'
23	Bottom pieces	2	4"x7"x7'8"
24	Spreader	1	3'10"x1'6"

Robert Linton, Trans. A. I. M. E., 1920.

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MINE TIMBER PRESERVATION *

PART I.

The purpose of this paper is to point out some of the benefits and economies to be derived by the better selection, preparation, storage, preservation and utilization of mine timber, and to give some specific information on certain wood preservatives and processes suitable for mine-timber preservation.

The paper is based largely upon data obtained by actual experimentation and service tests conducted by the U. S. Forest Products Laboratory, Madison, Wis., on wood preservation, covering a period of many years, and upon a field survey during the past summer (1921) by one of the mining engineers of the U. S. Bureau of Mines of some of the principal mining districts of Michigan, South Dakota, Montana and Idaho, in which he made a general study of mine timber in metal mines, particular attention being given to timber decay; the conditions under which it takes place most actively; the measures, if any, that are being used to combat it; and, finally, the advantages that might be anticipated in the use of chemically treated timber to prevent decay and thus prolong its life.

High cost production and low priced materials, due to post war conditions, have brought about an unusual situation in the mining industry, which must be met by a careful analysis of mining methods and costs in order to affect economies in operation. This may to a large degree be brought about by a standardization of mining practice and equipment.

With a view to effecting important savings, the problem of better distribution and utilization of materials and supplies is brought to the attention of the mine operator.

Importance of Mine Timber Preservation

The enforced closing of the large copper and iron mines throughout the United States has brought forcibly to the attention of the mine operators the tremendous cost of maintenance of mine timber in the main arteries of haulage and ventilation. This large maintenance cost in the monthly expense statements has brought the operator face to face with the problem of timber renewals, heretofore more or less obscured by the more pressing problems of production.

One phase of this problem is the chemical treatment of timber in which the mechanical life will exceed the natural life.

In the Butte district treated timber has been in use for several years, considerable attention being given to the use of cement applied by the cement gun for fire prevention. Also use is made not only of creosoted timbers but also of natural copper sulphate waters; a case of the latter use showing an increase of the life from three to ten years with the timbers still in good condition.

It is obvious that economies will result from the use of timber treated with some preservative of recognized merit, if the life of the working place is greater than the natural life of the untreated timber, whether the shortening of this natural life might result from decay or crushing.

Timber Becoming More Costly and More Difficult to Obtain

Throughout most of the mining regions of the United States, timbers are becoming more difficult to obtain, and naturally more costly; and the better varieties are rapidly becoming exhausted. The result is that the less durable varieties of timber are in use.

The only practical way to prolong the life of these less durable timbers is by chemical treatment to prevent decay, although much may be accomplished by giving greater care to the preparation and storage of the timber before it is used.

Great Expense of Frequent Timber Renewals

One of the principal items of expense is the maintenance of mine haulage ways and airways. Timber is usually employed for the support of these passages, since to date it has been found cheaper and more easily placed than steel or concrete.

The initial cost of an average sized tunnel set varies greatly with the nature of the ground and the location of the mine with reference to labor, material and transportation, but it may safely be said that the average set will cost between $12.00 and $15.00 in place, either in the coal or metal mining regions. Where heavy ground or excessive flow of water is encountered, the cost, of course, would be greatly increased.

Under the ordinary conditions of humidity, warmth and sluggishness of atmosphere, especially in metal mines, it is not uncommon for timber to become completely decayed in two or three years, sometimes in one year. Obviously the cost under these circumstances is enormous. These costs may be enumerated as follows:

(1) Cost of new timber.
(2) Labor cost in renewal.
(3) Loss due to serious interruption of mining operations.

Usually the cost of renewal is as great and sometimes greater than the original cost, while the labor cost varies from 50% to 100% or more than the original cost of placing the timbers. This increased cost is due to the delay in traffic with resultant loss in mining operations. The latter is serious but difficult of determination.

Vitiation of Mine Air By Decaying Timber

Large quantities of decaying timber, with the resultant heating and vitiation of the mine air, has an important bearing on mine ventilation. This also lowers the efficiency of the men, thus reducing their output.

Due to the greater depths of our metal mines, and the increasingly difficult problem of figuring the air necessary for the workmen, it becomes

*Abstracted from article by R. R. Hornor (Mining Engineer, U. S. Bureau of Mines) and George M. Hunt (in charge Section of Wood Preservation, U. S. Forest Products Laboratory, Madison, Wis.) Presented at February, 1922, meeting of A. I. M. & M. E.

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necessary to determine the amount of oxygen absorbed by the enormous amount of decaying timber under varying conditions of warmth and moisture in the old workings, and approximately the amount of heat given off. It is hoped that it may be possible for the Forest Products Laboratory to carry on some experiments in this direction to supplement the little information now available on this important problem.

Fire Hazard

Decaying and punky timber, especially where the bark has not been removed, is a considerably greater fire menace than sound peeled timber; therefore any steps to prevent decay of timber will be welcomed as lessening the fire hazard.

Preparation and Storage of Mine Timber

One of the simplest and most effective means for prolonging the life of mine timber is proper preparation and storage. By preparation is meant peeling and seasoning.

Seasoning mine timber, like peeling, has the following advantages: (1) increases the strength and in some cases the durability; (2) decreases the weight and thereby reduces the cost of freight and handling; (3) protects from insect attack and decay before the timber is placed in service; and (4) makes the timber more easily susceptible to preservative treatment.

Actual tests show that the strength of thoroughly seasoned timber is from 25% to 50% greater than that of green timber. There is some difference of opinion as to the increase in durability, although the observer is of the opinion that under most conditions the life of the seasoned and peeled timber is greater, due to its greater resistance to fungus attack.

One of the greatest advantages in seasoned timber lies in the fact that a well-seasoned timber is from 15% to 35% lighter than in its green state. This means a great saving in freight.

Proper storage is essential for proper seasoning. Timber yards should be well drained, dry and free from vegetation and decaying wood. The timber should be piled on skids a foot or more off the ground, and so piled as to insure a free circulation of air.

Use of Treated Timber

The reasons for the neglect of timber treatment in the mining industry, in spite of its extensive use in railroad, telephone and telegraph industries, are two-fold; first, lack of incentive due to the cheapness of mine timbers in the past; second, lack of knowledge of advantages, methods, chemicals and costs. Even though for ten or fifteen years both metal and coal operators have used treated timbers, the quantity used compared to the total amount of timber used is insignificant.

To secure the full benefits, the same care must be given to the preservative treatment as to other phases of mine operation. Timber preservation, to give effective results, must be practiced according to well established scientific principles. Frequently timber treatment has been condemned as of no value because the treated timber did not give the expected results, but in the majority of cases the failure was due to imperfect treatment or the adoption of some preservative agent not of recognized standard.

The economic side of timber treatment has the greatest interest for the mine operator, and he is usually keenly alert and quick to adopt any sound practice by which he may lower the cost of production. For his consideration the following economies resulting from the use of treated timbers are enumerated: (1) reduces cost of maintenance and thus effects a saving in labor and timber; (2) inferior grades of timber may be used, which are usually cheaper and more accessible than the more durable grades; (3) reduces loss from delays and interrupted production often caused by timber repairs and renewals; (4) saves cost of supervision and overhead expenses due to repairs and renewals; and (5) lessens timber consumption per ton of ore mined, and consequently lessens the cost of production per ton.

While no claim is made that it would be advisable to treat mine timber for all purposes, yet it is believed that in the majority of coal and metal mines there is usually a sufficient quantity of timber used in working places of more or less permanent nature, where the use of treated timber would be amply justified and would result in marked economy.

PART II.

By the law of the survival of the fittest, a few preservatives have survived nearly 100 years of practice in the preservation of wood; and these few have come to be considered standards. The value of several methods of preservation has been quite well determined also. There is of course a constant search for new materials and methods, but in this search we can only measure their value by comparing their results with the results of the accepted standards.

Standard Preservatives

Of all the preservatives which have been used in this country zinc chloride and coal tar creosote are most generally accepted and most widely used. Other materials of known preservative value, but which for one reason or another are less widely used are sodium fluoride, mercuric chloride, copper sulphate, water gas tar oils and wood tar creosotes. A brief description of each of these materials and a discussion of their properties follows.

Coal tar creosote is made from coal tar by distillation. It is a black or brownish oil and contains a great many different chemical compounds. Its exact composition is not known but it is known to vary appreciably, depending upon the kind of coal tar used in its manufacture and the method of distilling it. Reasonable variations are of no importance to the consumer, for long experience has shown that coal tar creosotes of widely varying characteristics will give entirely satisfactory protection against decay. In order to establish trade standards, however, and to prevent adulteration, standard specifications have been adopted which are used by most purchasers of creosote in quantity. The creosote specifications of the American Wood Preservers' Association are very good.

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A number of so-called refined coal tar creosotes are being sold under various trade names and actively promoted by their manufacturers. These oils do not have a greater preservative value than coal tar creosote, but they have have certain advantages, such as being more readily obtainable in small quantities. Some of them remain liquid at low temperatures, which is sometimes an appreciable convenience. The established proprietary creosotes and carbolineums (which are similar oils) can be depended upon for good results when properly used.

The price of creosote oil depends upon the quantity and quality of oil used and upon market conditions. Plants which consume large quantities of creosote commonly make long-time contracts and are thus enabled to secure the most favorable prices. There was a severe shortage of creosote during the war, and prices naturally mounted. Within the past year, however, marked reductions have been made and prices as low as 14 cents per gallon at seaboard have been mentioned. From this point on up to 50 cents or more per gallon may be asked, according to conditions. The highest prices are, of course, for small quantities of proprietary oils.

Coal tar creosote is a most effective wood preservative. No preservative has been found which will give wood better protection against decay. This is due to the high toxicity of the oil or its ability to poison the wood, its chemical stability, and its very low solubility in water. Once in the wood it remains there for many years, and where creosote is decay cannot proceed.

Objection is sometimes made to the color and odor of creosote and the fact that in hot weather it burns the skin of some workmen, like sun-burn. These are admittedly disadvantages, but they are not of great importance and ordinarily need be given but little consideration. Millions of gallons of creosote are used annually for treating piling, railroad ties, poles, posts, mine timbers, and various other structural timbers with but little thought of these disadvantages.

Creosote is sometimes objected to because of its supposed fire hazard. Opinions vary as to the extent to which it increases the inflammability of the wood, and many engineers believe that this is more imagined than real. There is little evidence to show that the oil adds appreciably to the hazard except perhaps when the wood is fresh from the treating tank. Instances are on record where creosoted wood has been less damaged by fire than untreated wood under the same conditions. A most important consideration which is usually lost sight of is that decaying wood is much more inflammable than sound wood. Fire is easy to start in decaying wood and difficult to extinguish. Creosote by preventing decay actually serves to make the fire hazard less than where untreated timber is used.

Zinc chloride is a metallic salt, soluble in water in all proportions. Solutions of about 3% to 5% strength are used in making timber treatments, but in order to reduce freight charges it is usually shipped in the solid form in air-tight drums, or in 50% solution in tank cars or drums. The importance of this salt as a wood preservative and its general wide use in this country are indicated by the fact that practically 50,000,000 pounds were used for preserving wood in 1920.

The quality of zinc chloride used in treating work is indicated by the following specifications which have been adopted as the standard of the American Wood Preservers' Association: "The zinc chloride shall be acid free and shall not contain more than 0.1% iron. Fused or solid zinc chloride shall contain at least 94% chloride of zinc. Concentrated zinc chloride solution shall contain at least 50% chloride of zinc."

On account of its solubility in water, zinc chloride is not as suitable as creosote for use in very wet places. Its principal use has been in the preservative treatment of railroad ties, and its proved effectiveness for this purpose shows that it does not wash out of the wood very quickly even when exposed to the weather. Although it cannot be considered as good a preservative as coal tar creosote it is quite good enough for many forms of timber and its advantages in other respects are responsible for its wide use.

The chief advantage of zinc chloride is its cheapness. One-half a pound of zinc chloride per cubic foot of wood is the amount ordinarily injected. At present prices this amount costs only about 3 cents, while creosote is much more expensive. Other advantages are its cleanness, its lack of odor and color, convenient shipment and storage and absolute freedom from fire hazard. Zinc chloride cannot be considered as a fire retardant and there is no evidence that it decreases the inflammability of wood. On the other hand, it certainly does not increase the inflammability of the wood and like creosote it keeps the fire hazard at a minimum by keeping the wood sound. On the whole, zinc chloride is a very satisfactory preservative for mine timbers and its use can be freely recommended.

Sodium fluoride is also a water soluble preservative, and like zinc chloride is injected in water solution. It is shipped as a white powder in wooden barrels and is mixed with water at the treating plant. It has not been used very widely in the United States as yet, but the results that have been obtained with it in this country and in Europe show that it is an excellent preservative. It has all the advantages possessed by zinc chloride, except cheapness. Its cost is considerably more than that of zinc chloride, and it is this fact that has prevented its more extensive use. Whenever it can be obtained at the price of zinc chloride its use will increase very rapidly.

Mercuric chloride or corrosive sublimate is a powerful preservative and its value is thoroughly established. It has been in use for preserving wood for nearly a hundred years. It has been used more extensively in Europe than in this country. The extreme poisonous nature of this preservative and the fact that it rapidly corrodes most metals, together with its high cost, have prevented its more extensive use. It is hardly to be recommended for mine timber preservation.

Copper sulphate has been used as a wood preservative in Europe for a great many years, and it is still used to a considerable extent. It is injected in water solution like other water soluble salts and has the same general advantages and disadvantages. Its chief disadvantages are its high solubility and its corrosion of iron and steel equipment. Its preservative value is not of the

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highest, yet it is sufficiently effective to justify its use when other conditions permit.

At least one mine in this country is making use of copper sulphate for preserving its timbers, and excellent results are reported. This is a copper mine in which some of the mine waters contain considerable quantities of copper sulphate. This water is dammed to form a pool, in which the mine timbers are soaked until they have absorbed a considerable quantity of the solution. Obviously, this method of treatment can be followed by but few mines in the country, but where it is feasible it affords a cheap and effective protection.

Water gas tar creosote is an oil made by distilling water gas tar. It is similar in many respects to coal tar creosote. It has not been used as extensively as coal tar creosote, but it is known to have considerable preservative value. It cannot be as freely recommended as coal tar creosote, but under certain conditions or in some localities its cost may be enough less than that of creosote or other preservatives to justify its use. It is often used for diluting coal tar creosote. This is an advantage only when the water gas tar product is much the cheaper.

Wood tar creosotes have not been used extensively enough to establish their value as preservatives. Ordinarily no consideration need be given to their use, but if conditions are such that a wood creosote of good quality can be obtained in sufficient quantities at a satisfactory price, its use may be advisable. Unless it can be obtained more cheaply than coal tar creosote, however, its use is not recommended.

New preservatives or treating processes are frequently promoted. Very commonly they possess little merit and the claims made by their promoters are not based on fact, but upon a lack of information on the fundamental principles of wood preservation and the value of the established preservatives and processes. The safest plan for the average consumer is to stick to the established standards and to leave to others the experimenting with new preservatives and their application.

Selecting a Preservative

It is not possible in a general article of this kind to recommend which of the above preservatives should be adopted by a mine. In general, the choice will lie between coal tar creosotes and zinc chloride. Special conditions may make the use of one of the other preservatives advisable at some mines, but ordinarily their use is not recommended.

Both zinc chloride and coal tar creosote are very satisfactory and one will not go far wrong in choosing either. They can both be applied by pressure or open tank equipment and both will effectively prevent decay. In arriving at a decision one should consider cost, length of life desired, weight of treated timber, prejudice of laborers and miners, fire hazard, and such other factors as may appeal to him. These factors will be given different weight by various engineers, and with the same data before them one may decide for zinc chloride and another for creosote.

Methods of Application

As with preservatives, one has also a variety to choose from in selecting a method of treatment. Methods are available to suit practically every need or condition. Treating processes may be divided into three general types, as follows: pressure processes, tank treatments without artificial pressure, and surface treatments.

Pressure Processes

Without question the most effective way to inject preservatives into wood is by means of pressure. This is done by placing the wood in closed cylinders and forcing the preservative into it by means of pumps. This is the standard method in use throughout the country by the railroads and other large consumers of treated timber. Its advantages are: (1) that better absorption and penetration of preservatives are possible with less waste of preservative than by any other means; (2) the time required for treatment is reduced to a minimum; and (3) a large volume of timber can be handled.

The only disadvantage is the expensive plant required. This makes pressure treatment practicable only where a considerable volume of timber is to be treated. It is not beyond the reach of mines, however, as pressure plants are now being operated by several mining companies. It is also possible for mines in some regions to purchase pressure treated ties and timber from commercial wood preserving plants. The use of pressure is strongly recommended wherever circumstances permit.

Tank Treatments Without Artificial Pressure

The hot and cold bath method is the most commonly used process of this kind. It consists in heating the wood for several hours in the preservative, then transferring it to a tank of cold preservative. In the hot tank the air and moisture in the wood become heated and expand and the wood is put in good condition to absorb oil. In the cold tank the air and moisture in the wood are cooled and contract, thus creating a partial vacuum in the wood and drawing the preservative into it. The same result can be accomplished in one tank by withdrawing the preservative at the end of the hot bath and refilling the tank with cool preservative. It can also be accomplished by discontinuing the heating at the end of the hot bath and allowing the wood and preservative to cool together.

The principal advantage of the hot and cold bath process is that with proper manipulation satisfactory treatments can be made with very inexpensive equipment. The size and character of the plant can be made to correspond with the quantity and character of the timber to be treated. Its disadvantages are that timber cannot be treated as rapidly or quite as thoroughly as by means of pressure. Many years' experience with the hot and cold bath process have thoroughly demonstrated its value, however, and its use is recommended where pressure treatment is impracticable.

Creosote oil has generally been used as the preservative in the hot and cold bath process, but zinc chloride solution can also be used, and very satisfactory results have been obtained with tim-

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ber treated with zinc chloride in this manner. In using zinc chloride there is likely to be some evaporation of water from the solution which will raise the strength of the solution beyond the desired point. This can be overcome by adding water to the solution occasionally as needed.

The steeping process is another non-pressure, tank process. It consists in simply soaking the wood for a long time in the preservative solution. An arbitrary rule which is often followed is to allow one day of soaking for each inch in thickness of the timber and then continue the soaking for one additional day. Any water soluble preservative may be used, and the only apparatus required is a tank. The advantages of the process are its extreme simplicity and the inexpensive plant required. Its disadvantages are: (1) the long time required for treatment which makes it possible to treat only relatively small quantities; and (2) the fact that deep penetration of the preservative is not likely to be secured. The process has considerable merit, however, and its use can be recommended if conditions prohibit the use of pressure or hot and cold bath treatment. Timber properly treated by the steeping process will last much longer than untreated timber, and the investment will be well repaid.

Surface Treatments

In this group are included the methods of treatment in which the surface of the wood is covered with preservative but little or no penetration is secured. Creosote oil is the preservative used, and it may be applied either by brushing, spraying or dipping. It is preferable to have the oil hot and to apply at least two coats when brushing or spraying. Dipping is accomplished by submerging the wood for a few minutes in a tank of hot preservative.

These treatments are inexpensive and they can be very conveniently made. They will not give nearly the protection afforded by the more expensive treatments and they are to be recommended only when it is impossible to use a more thorough method. They may add one to three years life to the timber and thus more than pay for the cost of treatment but they will not give the durability desired in timbers in permanent passageways.

Which Process Should Be Used?

In full accord with the law of compensation, the results secured from treated timber will depend in large measure upon the investment of money and thought put into the treatment, assuming of course that it is used efficiently and not wasted. The more carefully and thoroughly the treatment is made the more satisfactory will be the results. It is recommended that first consideration be given to pressure treatment and that it be adopted if practicable.* When conditions do not warrant the investment in a pressure plant the hot and cold bath process should be used. Seldom will it prove impossible to use either of the above processes, but when they are out of the question one of the simpler processes should be used.

Plant Equipment and Cost

The equipment required for applying preservatives depends upon the preservative and especially upon the process used, as well as upon the volume of timber to be handled. It is impossible, therefore, to be very specific as to details of equipment. There are certain standard pieces of equipment, however,

*In this connection it is well to remember that timber used above ground is benefitted by treatment as well as timber for use in the mine. Underground and surface timber together may make a total sufficient to justify a pressure plant where either alone would not.

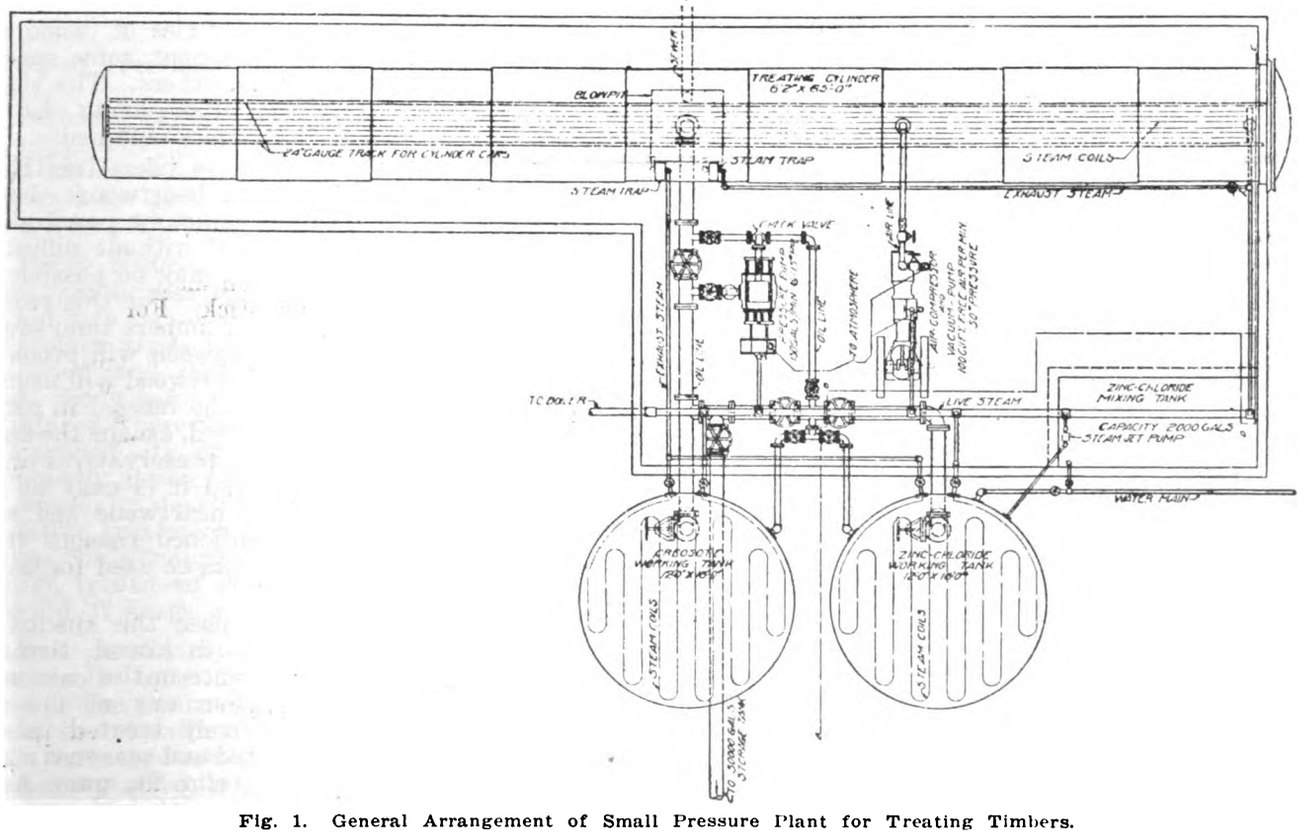

Fig. 1. General Arrangement of Small Pressure Plant for Treating Timbers.

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which are required, although they may vary as to details.

In a pressure plant there must be one or more treating cylinders built to withstand high pressures, preferably up to 150 to 200 pounds per square inch, and equipped with steam coils, connections for live steam, preservative and vacuum. There must be treating cars for carrying the wood in and out of the cylinder and holding it during treatment, a vacuum pump, pressure pump for injecting the preservative, working tanks, storage tanks and mixing tanks for the preservative, power for moving the cars and plenty of steam for operating pumps and heating coils.

Fig. 1* shows the general arrangement of a small pressure plant suitable for mine timber treatment. It has a capacity of about 1,000 cubic feet of wood per charge. In well seasoned wood two or three charges per 24-hour day might be treated. The cost of such a plant erected about 15 years ago, including the necessary yard construction, was $12,000 to $20,000. At present prices it might cost 50% to 100% more.

Fig. 2 is a sketch of an open-tank plant suitable for mine timber treatment. The principal items of equipment are two treating tanks, three treating

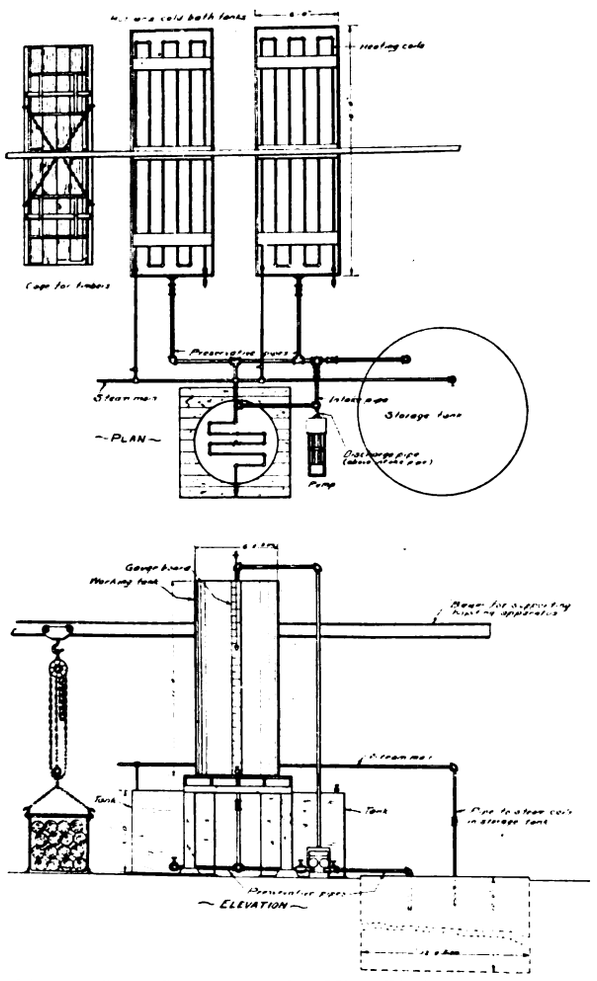

Fig. 2. Open Tank Plant for Mine Timber Treatment.

cages, a working tank, a storage tank, preservative pump, hoisting pulley with overhead track and a steam supply. One-quarter inch steel is suggested for the treating and working tanks and for the treating cages, and 5/8-inch steel for the storage tank. The total weight of metal in the plant in the size shown would be about 7 to 8 tons. (This does not include a steam boiler.) Exact data on the cost of such a plant is not available, but it would probably be around $1,400 to $1,600. The cost, of course, will vary with local conditions, labor costs, freight, etc.

It is often possible to construct open-tank plants at very small cost out of old tanks and apparatus on hand. When efficient plants can be constructed in this way it is, of course, advisable, but it is not advisable to sacrifice efficiency of operation and effectiveness of treatment for the sake of getting a low plant cost. The inefficiency of a makeshift plant may result in greater labor costs which will in a very short time offset any advantage gained in first cost. If it results in poor treatment, which is quite possible, the full benefits possible from preservative treatment will not be realized and an indirect loss of considerable magnitude will thus result.

The various types of equipment and details of construction make it possible for a mine to equip itself at almost any cost which is considered permissible. It is recommended, however, that the design of the plant be determined only after careful consideration of the needs of the mine. The primary considerations should be cost and effectiveness of treatment and efficiency of operation under the conditions existing at the mine in question. The first cost of the treating plant should be secondary consideration. In arriving at these conclusions it will be a paying investment to secure the assistance of an engineer familiar with wood utilization problems, wood preservation and plant construction.

Susceptibility of Various Species and Forms of Wood to Treatment

Although practically all species of wood are benefitted by preservative treatment, some species are much easier to treat than others. The shape of the timber and its degree of seasoning also influence very materially the results obtained.

The sapwood of most species takes treatment much more readily than the heartwood. It is usually possible to get a satisfactory penetration of preservative in the sapwood without difficulty while only a slight penetration may be possible in the heartwood of the same stick. For this reason it is much easier to treat round timbers than sawed timbers. In sawed timbers sapwood will probably be found on the corners, but heartwood will usually be exposed on one or more of the faces. In round timbers the whole surface exposed, except the ends, will be sapwood. Fortunately, preservatives enter wood endwise quite readily and it is easy to get good end penetration in both heartwood and sapwood. For the above mentioned reasons it is recommended that round timbers be used for treatment wherever it is possible.

When round timbers are used the species of wood is not so important as in sawed timbers. Although there is some difference in the ease with which they absorb preservative, any of the following species can be effectively treated in the round form if properly prepared and seasoned: ash, beech, birch, cedar, chestnut, elm, fir, gum, hemlock, hickory, larch, maple, oak, pine, spruce, syca-

*From Forest Service Bulletin No. 107.

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more, and tamarack. This is not intended to be a complete list of species which can be treated, as practically all species are improved by treatment, but it probably covers most of the species likely to be used for mine timbers.

Another advantage in using round timbers is that the deeper penetration which they make possible affords more protection against damage to the treated portion by abrasion, blows or careless handling. When the treated layer is broken through in any manner, untreated wood is exposed to decay and the effectiveness of the protection is thus materially reduced. Careless handling or cutting into the timber in any way after treatment should be avoided, and all framing should be done before treatment. A certain amount of damage is unavoidable, however, and the presence of deeply penetrated sapwood is, therefore, a distinct advantage.

The susceptibility to treatment is influenced to a great extent by the condition of the wood at the time of treatment. Seasoned timber is much easier to treat than green or unseasoned timber. A larger amount of preservative can be injected, and a better penetration secured. This results in longer life. It is not impossible to treat green or partly seasoned timber. With long heating periods and high temperatures considerable penetration can be obtained in some species. This requires a long time, however, and runs up the expense of treatment and also generally gives imperfect results. Thorough seasoning preliminary to treatment is by far the better practice and should never be omitted if at all practicable.

It is necessary, of course ,that the timber be peeled before treatment. Preservatives do not readily penetrate through bark and a good penetration can be obtained only in peeled timber.

Effect of Treatment on Strength

Although there is no evidence to show that preservative treatment increases the strength of wood, it is an established fact that treatment greatly increases the ability of wood to carry a heavy load for a long period of time.

Decay reduces the strength of wood much more rapidly than is generally supposed. Decay is caused by a very low order of plant, called a fungus. This plant sends its microscopic threads through the wood and dissolves certain portions for its food. Long before the wood appears to the eye to be injured, these threads have permeated the wood and sapped its strength. Many a mine timber, supposedly destroyed by crushing, has first been weakened by decay to the point of failure. Preservative treatment prevents decay and thus conserves the strength of the wood. Therefore, although treatment does not increase the strength of wood, it keeps wood strong.

It is possible by using high temperatures and excessively long treating periods to injure the wood by the treatment. This is only likely to occur when the treatment is very carelessly made or when very severe measures are being used to force the preservative into green wood or into some species which is very hard to treat. The ordinary treatments will have no appreciable effect on strength.

If very strong solutions of zinc chloride are used, it is also possible to injure the wood. For this reason it is customary in wood treatment to use solutions of 2% to 4% strength, and never over 5%. These solutions are safe to use and do not affect the strength appreciably. Their extensive and successful use for so many years in treating railroad ties and timbers of various kinds is ample proof of their fitness.

Effectiveness of Treatment as Shown by Service Records

The surest method of determining the effectiveness of preservative treatment is to observe the relative life of treated and untreated timber under service conditions. Fortunately, tests of this kind were started by the Forest Service many years ago in co-operation with a number of mines in various parts of the country, and we now have the results in years of observation.

In the spring and summer of 1910 there were placed in one of the mines of the Tennessee Coal, Iron & Railroad Company, near Birmingham, Ala., 50 untreated sap pine ties, 50 similar ties treated with 8 pounds of coal tar creosote per cubic foot, and 50 untreated white oak ties. Frequent inspections have been made of these ties since that date. At the end of five years about 68% of the untreated pine ties had been replaced or rendered worthless by decay. Their average life was, therefore, something less than five years. Further inspections of these ties were prevented by the closing of the gangway. At the end of 10½ years 26% of the oak ties had been removed on account of decay and 74% of them were still good for further service. At this time all of the creosoted pine ties were still in service, and although some of them showed traces of decay, they were all good for a number of years to come. This is an unusually good record for white oak ties, still the creosoted pine ties are making a better showing. The creosoted pine ties have been in service over twice as long as the untreated pine, and they may last three times as long. Inspectors of these timbers are still being continued, so that their complete record will in time be available.

Another test on mine ties was started in co-operation with the Tennessee Coal, Iron & Railroad Company in 1914 with sap pine ties treated as follows:

Coal tar creosote.....	50 ties
Sodium fluoride	150 ties
Zinc chloride	150 ties
Mixture of zinc chloride and sodium fluoride.....	150 ties
No treatment	94 ties

The treatments were all made by pressure. The creosoted ties were given an absorption of 10 pounds per cubic foot. The others had various absorptions from ¼ to ¾ of a pound of the chemical per cubic foot.

At the 1920 inspection, after about six years' service, the creosoted ties were all in perfect con-

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dition. Some of the ties treated with zinc chloride and some with sodium fluoride were showing traces of decay, but about 75% of them were still absolutely sound. All but 12% of the untreated ties were affected with decay and about 13% of them needed to be removed. The untreated ties in this test also are giving longer service than would ordinarily be expected, but the treated ties are giving still better service. It will require a number of years yet to complete this test and determine the relative life of the different groups, but the superiority of the treated timber is already apparent.

A test on mine timbers was also started at Birmingham in 1910 in the Sumpter mine of the Tennessee Coal, Iron & Railroad Company. Ten sets of sawed heart pine posts and caps were placed without preservative treatment, and along with them 64 sets pressure treated with 6½ to 9½ pounds of creosote per cubic foot. The last inspection of these timbers was made in 1919 after about 9½ years' service. At this time all of the untreated timbers had been removed and all of the treated ones were still in service. The average life of the untreated timbers in this test was 9.4 years, which is probably unusually good. The untreated timbers were scattered among the treated ones, however, and as they decayed the treated timbers carried the load. If all the timbers had been untreated this could not have been done and they would have had to be removed in a shorter time.

Within a year after this inspection this section of the mine was abandoned and allowed to fill with water, thus preventing further inspections and preventing the full value of the creosoted timber being realized. The treatment had well paid for itself, however, as the untreated sets had already been renewed once. The cost of labor and materials for replacing the untreated sets was much higher than the original cost of installation, coming as it did at a period when these things were at a maximum. In the treated timbers this expense was saved.

Inasmuch as all the above treatments were pressure treatments, they do not give information on the value of non-pressure treatments. At Pottsville, Pa., however, a large number of timbers treated by open tank or other non-pressure processes were installed in 1906, 1907 and 1908. Untreated timbers were placed at the same time for comparison. At the various inspections since that time it has not been possible to inspect all the timbers or to obtain complete data upon them, as at each subsequent inspection an increasing number are found to be in closed gangways. However, the data is sufficiently complete to establish the following:

1. All of the untreated material failed in one to three years. Its average life was about two years.

2. Timber brush treated with creosote or carbolineum remained serviceable for three to four years.

3. Of the open tank treated timbers, which are still in accessible places or on which complete data are available, 69% are still in service and 31% are decayed after 13 to 15 years' service.

The average life of these timbers has not yet been reached, although they have already lasted six to seven times as long as the untreated timber. Of the open tank timbers, included in the above figures, some were treated green and some seasoned with each of the following preservatives: coal tar creosote, water gas tar creosote, and zinc chloride.

Much better results were obtained with the seasoned than with the green timbers and the majority of the timbers decayed to date are those which were treated in the green condition. The creosote is giving somewhat better results than the zinc chloride, but the difference so far is not very great.

That the treated timbers are in places favorable to decay is shown by the fact that a treated post, found decayed after about 13 years' service, was replaced by an untreated post in 1919. One year later the new post was found decayed. The advantage of using the treated timber is clearly shown.

It will be noted that the life of the untreated timber in the Pottsville experiments was much less than in the Birmingham experiments. This is due, in part, to the character of timber used and in part to the difference in the severity of the conditions. Treated timber will show to the greater advantage, of course, where the life of untreated timber is short.

Other experiments on mine timbers are under way at the Bunker Hill and Sullivan mine at Kellogg, Idaho; the Hercules mine at Burke, Idaho; the Delaware, Lackawanna & Western mines at Scranton, Pa., and the Anaconda mine at Butte, Mont. In all these experiments the superiority and economy of treated over untreated wood has been shown. It is no longer a question as to whether treatment increases the life of the wood, but a question as to the kind of treatment and preservative that pays the biggest dividends under various conditions.

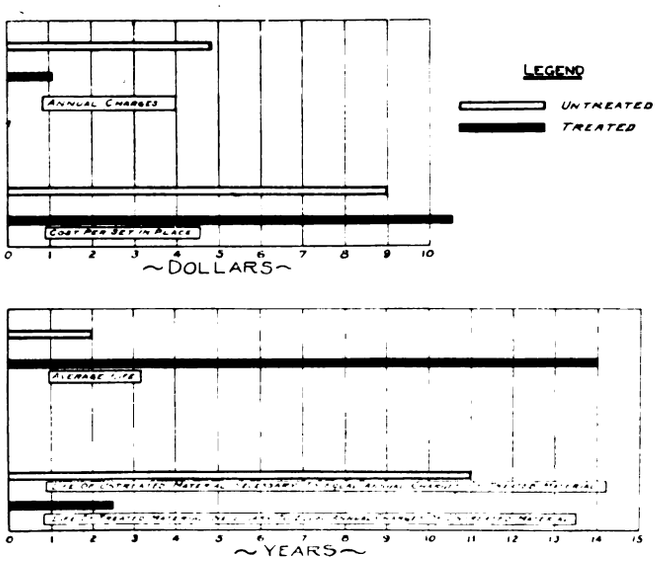

Fig. 3. Comparison of Tank Treated and Untreated Timbers in Pottsville Experiment.

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TABLE I. ANNUAL CHARGES DUE TO AN INITIAL EXPENDITURE OF ONE DOLLAR.*

Interest Rate	Term of Years																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	22	24	26	28	39
4%	1.04	0.530	0.362	0.275	0.225	0.191	0.166	0.148	0.132	0.123	0.114	0.106	0.100	0.094	0.086	0.079	0.073	0.069	0.065	0.062	0.060	0.058
5%	1.05	0.538	0.367	0.282	0.231	0.197	0.173	0.155	0.140	0.129	0.120	0.112	0.106	0.101	0.092	0.085	0.080	0.076	0.072	0.069	0.067	0.065
6%	1.06	0.545	0.374	0.288	0.237	0.203	0.179	0.161	0.148	0.135	0.126	0.119	0.112	0.107	0.098	0.092	0.087	0.083	0.079	0.076	0.074	0.070
7%	1.07	0.553	0.381	0.295	0.243	0.209	0.185	0.167	0.153	0.142	0.133	0.128	0.121	0.116	0.109	0.103	0.097	0.092	0.088	0.086	0.083	0.081
8%	1.08	0.561	0.388	0.302	0.250	0.215	0.192	0.174	0.160	0.149	0.140	0.133	0.127	0.121	0.113	0.107	1.102	0.098	0.095	0.093	0.090	0.089
9%	1.09	0.568	0.395	0.309	0.257	0.223	0.199	0.181	0.167	0.156	0.147	0.140	0.134	0.128	0.120	0.114	0.110	0.106	0.103	0.101	0.099	0.097
10%	1.10	0.576	0.402	0.315	0.263	0.227	0.205	0.187	0.173	0.162	0.153	0.146	0.140	0.135	0.128	0.121	0.117	0.114	0.110	0.109	0.106	0.105

*Based on the formula, $A = P \frac{(1+r)^n r}{(1+r)^n - 1}$, in which A = annual charge.
P = amount of initial invest
n = number of years in the recurring period (the average life of the timber.
r = the rate of interest expressed decimally.

Does It Pay

Although treatment makes wood last longer, it cannot hope for extensive use unless it reduces the timber expense.

Table I. offers a ready means of comparing the cost per year of treated and untreated timber and thus determining the savings due to treatment. The table is based on the well known Fernow* formula for determining the equivalent annual charge due to an initial expenditure now and recurring each term of "n" years.

The above data obtained in the Pottsville experiment show the savings possible. At the time the experiment was started, timbers for permanent gangways were costing $4.50 per set for the material, 50c for framing and $3.00 for placing. In addition it cost $1.00 to remove the old set to make way for the new. The timber on the average lasted two years. An expenditure of $9.00 per set was, therefore, required every two years, with the certainty that this cost would rise as timber became scarce and labor higher. The most expensive treatment used (treatment with coal tar creosote) cost at that time $1.55 per set, making the cost of this treated set, in place, $10.55. The average life of this treated timber has not yet been reached, but it will be at least 14 years.

Turning now to the table, we find that if we assume an interest rate of 5% and take two years as the average life of the untreated timber, the annual charge for each dollar invested in the untreated set is $.538. Since the untreated sets cost $9.00, in place, the total annual charge per set would be $4.84. In the same way, we find that the annual charge for the treated timber, assuming an average life of 14 years, is $1.07 per set. The use of the treated timber is therefore resulting in a saving of $3.77 per set per year. Putting it in other words, the cost of maintaining a set of untreated timbers would maintain approximately 4½ sets of treated timber. It may also be computed from the table that in order to give the same annual charge as the untreated timber, the treated timber would have had to last but about 2½ years. Conversely, the untreated timber would have had to last over 11 years to be as cheap as the treated.

In mines where untreated timber shows a long life, the savings due to treatment will be less than where the untreated timber is short lived. It is possible, however, that the conditions which would give a long life to untreated timber would also give a proportionately longer life to treated timber. The relative cost of treated and untreated timber will also affect the magnitude of the savings. The rate of interest assumed will affect the results to a slight degree; higher interest producing lower savings. By means of the table it is possible for the operator to determine whether treatment will pay under the conditions existing at his mine, and thus to reach an intelligent decision as to the use of treated timber.

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STRENGTH OF MINE TIMBERS*

The ordinary handbooks that are available for the use of miners and timbermen seem to contain very little information on the strength of timbers that are commonly used in and around mines.

In fact, there is less known about the strength of wood than any other structural material.

Wood is used in such tremendous quantities around the mines that it would seem that the State Mine Inspectors, Accident Commissions, and even the Bureau of Mines, should furnish ready tables for miners.

Many times I have been asked to prepare tables for operators, who wished them for their own reference, generally from desire to increase the safety factor that the industrial insurance rate might be lowered.

The increasing number of requests makes it advisable that they be put in print in the most convenient and simplest form in the hope that the greatest number may benefit by them.

In "squeezing ground," when the thrust or load is applied horizontally, these figures may be used for horizontal stulls and braces, provided the center of the stull is properly supported to hold its weight and prevent buckling or bending.

In tunnel timbers, where the posts are set at an angle, with the bottom or floor of the tunnel wider than the cap, the weight that the post will carry is reduced by the pitch of the timber. Two timbers set like a letter "A" will not carry as much weight as the same two timbers standing like a post under the load. The load varies with the angle of the incline.

Example: An "A frame" of two 6-in.x6-in. timbers 6 feet long at 45 degrees will support 42 tons, whereas the two 6-in-x6-in. set as posts under the load will support 60 tons (30 tons for each post). If spans are braced loads may be increased.

A common error is in using timbers too big and all out of proportion to the load they are called upon to sustain. This is undue extravagance, and they are no safer than timbers of the right size, and often last no longer under ground; though, to the mine inspector, oversized timbers do not offer the objection that undersized timbers offer. However, with the increasing price of lumber and timbers, this useless waste is not only reducing the dividends, by increasing the expense, but it is wasteful of the lumber and causes the price to still further increase.

The other extreme of undersized, or overloaded timbers, is not only dangerous, but causes enormous expense in too frequent replacements, which is also wasteful of lumber, and frequently increase the maintenance expense in cleaning up the result of caves and broken timbers, if not indeed the loss of some part of the mine.

For the benefit of all concerned I have not copyrighted these tables, that publishers of handbooks and magazines, mine inspectors, accident commissions, and insurance companies may reprint as they see fit.

*By Letson Balliet Efficiency Engineer, 1508 Hobart Building, San Francisco, Calif.

SAFE LOAD IN TONS

Safe load in tons, for timbers when used as posts, stulls, center pieces in shaft timbers, in head frames, trestles, and supports for orebins and buildings. The figures are for first grade pine timbers, allowance to be made for poorer grades.

Size of Posts or Stulls	Length of past or stull in feet											
	6	8	10	12	16	20	24	28	32	40	50	60
4x 4 ..	9	8	7	5½	2½							
6x 6 ..	30	22	20	18	14	10	5					
8x 8 ..	52	53	51	37½	32	26	21	16	10			
10x10 ..	82	82	82	82	55	50	42	35	30	17		
12x12 ..	120	120	115	115	90	80	70	62	55	38	20	
14x14 ..	160	160	160	160	160	120	105	95	85	68	45	23

The weight on long posts may be increased if they are braced to prevent buckling or bending.
Table by Letson Balliet, E. M. & C. E.

LOADS ON PLANKS

Table of safe loads that can be placed on planks over shafts and winzes, and upon staging, or when used as lagging in shafts and tunnels. The loads are figured for the center of the span, and may be doubled when load is distributed.

Sizes of Planks and Lagging	Length of Spans in feet							
	4	6	8	10	12	14	16	18
	Safe load in pounds							
2x10	900	600	450	325	275	225	175	100
2x12	1100	700	550	400	325	250	200	160
3x12	1800	1200	850	670	500	400	320	250
4x12	2500	1800	1300	1000	800	600	470	380

Table by Letson Balliet, E. M. & C. E.

SAFE LOAD FOR TIMBERS

Safe loads for timbers of first grade pine, when used for beams, girders, wall plates, and plates, caps and bents. Load is figured in pounds, for safe loads, not breaking loads.

Size of Timbers	Length of Span in feet									
	4	6	8	10	12	14	16	18	20	24
2x 4	800	505	350	275	225	185	160			
4x 4	1500	1000	700	600	450	400	325			
4x 6	3500	2300	1600	1300	1100	1000	800	650	560	
6x 6	5000	3500	2500	2000	1600	1400	1200	1000	850	
6x 8	8600	5750	4500	3500	2800	2400	2100	1800	1600	1250
8x 8	11500	8000	5800	4600	3800	3200	2700	2400	2100	1700
8x12	20000	17000	13000	11000	8500	7200	6300	5500	5000	3900
8x14	22500	22300	18000	14500	12500	9800	8500	2600	6500	5400
8x16	25500	25400	23500	19000	15500	13000	11500	10000	8800	7100
10x10	20000	15500	11000	9000	7500	6300	5500	4700	4200	3400
10x12	24000	22000	16500	13000	11000	9000	7800	6900	6100	5000
10x14	28000	27800	22500	18000	15000	12500	11000	9400	8300	6800
12x12	29000	26000	20000	16000	13000	11000	9500	8200	7400	5900
12x14	35000	34000	27000	22000	18000	15000	13000	11500	10000	8000
12x16	38500	38000	34500	28000	23000	20000	17000	15000	13500	11000
14x14	40000	39000	31000	25000	21000	18000	15000	13000	12000	9800

Loads are figured at the center of the span, and may be doubled for loads that are equally distributed throughout the length of the span—PROVIDED that doubling does not exceed the figures given in the first column, for spans of four feet. The bearings at the end of the span must have an area equal to a section of the beam.
Table by Letson Balliet, E. M. & C. E.

SAFE LOADS FOR TIMBERS AT AN INCLINE

Hor. Dist.	Vert. Dist.	Angle from Vert.	Per Cent. of Vertical Load Allowable
1' in	1'	45°	70%
1' in	2'	27°	80%
1' in	3'	19°	94%
1' in	4'	14°	96%
1' in	7'	8°	98%
1' in	10'	6°	99%

Long spans may be braced to prevent buckling.

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SAMUEL CABOT, INC.

Manufacturing Chemists

342 Madison Ave.
NEW YORK, N. Y.

141 Milk Street, BOSTON, MASS.

24 W. Kinzie Street
CHICAGO, ILL.

CONSERVO WOOD PRESERVATIVE

A penetrating, permanent preservative for mine timbers and all other lumber.

Description

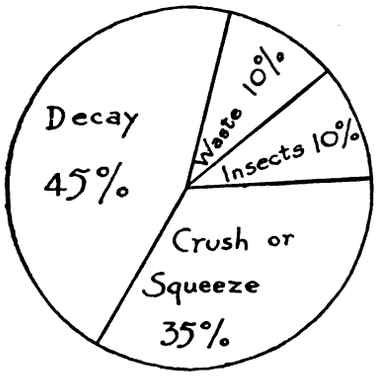
Conservo is a compound of high boiling coal-tar distillate, non-volatile, insoluble, non-viscous, and antiseptic. Its tone on wood is rich butternut brown.

It is a scientific product made to cover the three cardinal principles of wood preservation, viz:

1. Penetrating Power.—No preservative can preserve unless it penetrates. Most heavy preservatives fail because they are so heavy and viscous that they cannot get into the wood, but remain on the surface and are washed off by rains or other moisture. Conservo is so limpid that its penetrating power is far greater.

2. Permanence.—Conservo is so non-volatile that it will not evaporate at any temperature to which it can be subjected after application. It goes in and stays in.

3. Sterilizing Power.—Decay is caused by bacteria, and Conservo has always carried the proper percentage of Tar Acids—7 to 10%—to sterilize the wood and poison the bacteria. The Tar Acids also increase the penetration and combine with the sappy parts of the wood and form asphaltic bases that are permanent.



The U. S. Government investigation shows that:

45% of Mine Timber is wasted by Decay.

10% more by Insects.

The Cost of Replacing is vastly more than the cost of the timber.

Covering Capacity

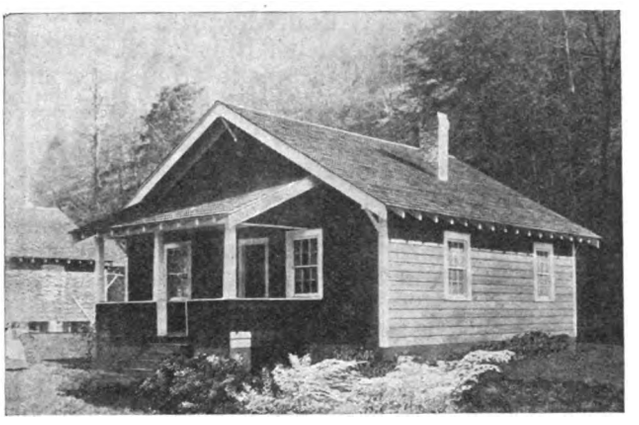
Brush Coating—One gal. covers about 100 sq. ft. of rough sawed lumber, two coats; 250 sq. ft. of dressed lumber, two coats.

Cost

Price, 70 cents per gallon, f. o. b. Boston. The cost of treating depends upon the method selected, the character and condition of the wood, and the economy of handling, which includes wages, waste, etc.

CABOT'S CREOSOTE STAINS

For preserving and economically coloring workmen's houses.



One of the Workmen's Bungalows Erected by the Carbon Fuel Co., Charleston, W. Va. and Stained With Cabot's Creosote Stains

Low Cost—50% Cheaper Than Paint

Cabot's Stains cost less than half as much as paint, and the cost of applying is also less than half because they can be put on twice as fast, with wide, flat brushes or a spraying machine. Any intelligent laborer can apply them.

Handsome and Lasting Colors

The colors are rich and handsome and they make the houses look homelike and attractive; real places to live in. They wear as well as the best paint.

Preserve the Wood

Cabot's Stains are made of refined Creosote, which penetrates the wood and preserves it against decay or insects.

Ideal for Housing

Thousands of gallons of Cabot's Stains are being used on housing by coal mining companies, such as Carbon Fuel Company, Buckeye Coal Company, Stonega Coal & Coke Company, etc., etc.

Samples of Colors, Prices and Full Information will be Sent on Request.

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THE AMERICAN ZINC PRODUCTS CO.

General Offices: GREENCASTLE, INDIANA

Manufacturers of

Old Chateau
ZINC ROOFINGS

Made From Pure Zinc Sheets

Products

Zinc Sheets for Cyanide Shavings.

"Old Chateau" Roofing and Siding, furnished in corrugated, and V crimped. All lengths desired up to and including 10 feet. Corrugated can be furnished 1¼" or 2½" any desired width.

We also manufacture Zinc Ridge Roll, V Capping, Valley, Flashing, etc., made from pure zinc sheets. Zinc sheets all gauges and sizes; Zinc Tiles for residences and other high class buildings.

"Old Chateau" Pure Zinc Roofing

The American people have long looked for a roofing material which could be used with assurance of long life, but until the war increased the production of zinc sheets in this country, they have looked in vain.

Copper could be secured, but the price was very high, in fact, too high to permit of use upon common buildings.

Zinc was known to be everlasting, but in this country the production was so small (only two plants) that sheets could not be obtained for roofing purposes.

The war changed this, as ZINC SHEETS HAD TO BE OBTAINED for powder box linings and many other war purposes, and therefore, production was materially increased, and now we can furnish "Old Chateau" Roofing Zinc in unlimited quantities at a price but little higher than galvanized (zinc coated sheets).

You have long known how much better a galvanized sheet was than an ordinary black steel sheet. The extra life was in the light zinc coating on each side of the steel sheet, at the present time about one-half ounce of zinc is used upon each square foot of surface.

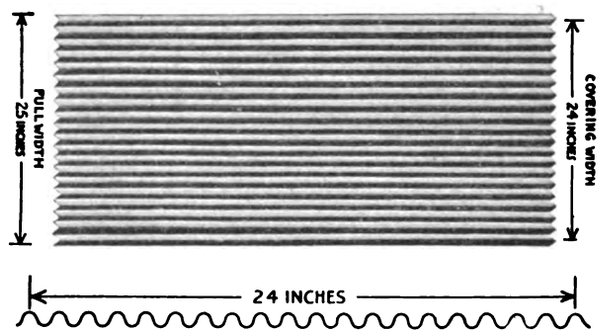
Pure Zinc sheets used in weather exposed places mean equal permanency with any other materials in the structure. The American Zinc Products Company offers to the permanent builder its "OLD CHATEAU" Roofing Brand of Sheet Zinc in full confidence that it will meet all exacting requirements. Rolled in even gauges from zinc pig, smelted in our own furnaces, it is handled from mine to sheet with the sole idea of furnishing a smooth, ductile weather-resisting covering, fit for castle or cottage and as enduring as any material in the structure.

More than a century ago the builders of Belgium and France realized the value of zinc sheets in weather exposed construction. Zinc roofs are now extant that were installed more than one hundred years ago. Gutters, flashings, eave-troughs, valleys and conductor pipes were made of zinc, and these articles are enduring far beyond the life of the masonry itself. In addition to this big saving in weather-wear, the zinc sheets can still be salvaged and sold at a price near the original cost.

As a weather resister, zinc stands pre-eminent among metals, neither atmosphere nor moisture has a perceptible effect on it. From the moment a zinc sheet is placed in use, or down to the day in another century when the other materials of the structure have crumbled or rotted away, it is still a sheet of zinc. The weather elements scarcely change it; it is yet worth its weight as zinc.

One and One-Quarter Inch Corrugated "Old Chateau" Zinc Roofing

Each sheet has twenty full corrugations, 1¼" from center to center. Full width, 24" when lapped one corrugation.

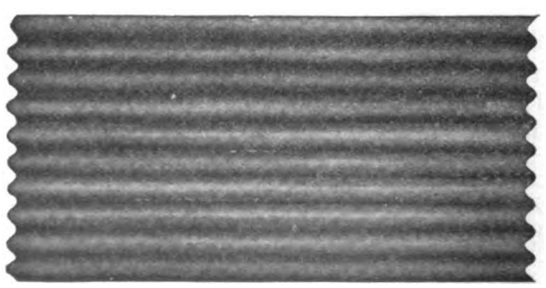


Standard lengths, 5, 6, 7 and 8 feet. Special lengths, 9 and 10 feet.

Approximate weights per square: No. 9 Gauge, 76 lbs.; No. 10 Gauge, 84 lbs.; No. 11 Gauge, 101 lbs.

Two and One-Half Inch Corrugated "Old Chateau" Zinc Roofing

Each sheet has corrugations, 2½" from center to center.



Sheets furnished in either ⅝" deep or special ⅞" deep corrugation in various widths to lay up to 36" weather exposure with either one or one and one-half corrugations side lap.

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Asbestos Shingle, Slate & Sheathing Company

AMBLER, PENNA.

Branch Offices and Agents

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HOUSTON, TEXAS—R. V. Aycock & Co.
KANSAS CITY, MO.—R. V. Aycock & Co.
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NEW ORLEANS, LA.—J. T. Mann & Co., Tchoupitoulas St.
NEW YORK CITY, N. Y.—828 Woolworth Building.
PHILADELPHIA, PA.—2013 Market Street.
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ST. LOUIS, MO.—R. V. Aycock & Co.
TULSA, OKLA.—R. V. Aycock & Co.
WASHINGTON, D. C.—623 F Street, N. W.

Distributors Throughout the Country

Products

Ambler Asbestos Shingles, Ambler Asbestos Building Lumber, Ambler Asbestos Corrugated Roofing and Siding, Ambler Linabestos Wallboard.

The Annual Fire Loss in the United States alone is in excess of $250,000,000.

And most of that fire money can be saved. As the fire loss increases, insurance rates increase with it.

Ambler Asbestos Building Products reduce the fire hazard. They are non-inflammable and cannot carry nor support fires. These products have been tested and approved as fire retarding materials by the American Society of Fire Protection and the National Board of Fire Underwriters' Laboratories.

Kinds of Material

Ambler Asbestos Building Products are made from selected Asbestos fibre and best Portland Cement.

Ambler Asbestos Shingles

The only shingles made under Hatschek's reissued United States Letters Patent No. 12,594, Jan. 15, 1907.

There is no reason why the roof of a house should not be as permanent as the foundation.

Ambler Asbestos Shingles cannot wear out—they withstand wear and weather; they afford protection against fire; there is no maintenance cost; they never require painting and are absolutely fireproof and flame resistant. Hundreds of thousands of roofs prove this statement.

Ambler Asbestos Shingles respond to every roofing requirement about the mine and can be laid by the usual class of labor found at the mine.

Ambler Asbestos Building Lumber

For siding, partitions, fire doors and wherever fire resistance is essential.

Ambler Asbestos Corrugated Roofing and Siding

Made in an incombustible concrete sheet, consisting of the best grade of Hydraulic Cement, reinforced with long asbestos fibres. These materials are first mixed together with water, and then taken up in layers until the desired thickness has been attained, and, in such a way that the asbestos fibres interlock and thoroughly reinforce the concrete sheet. It is then subjected to enormous pressure between steel plates, which drives out all excessive water and eliminates all voids and fissures and produces a sheet that is strong and tough and which will not rot, rust or decay. Concrete will harden and improve with age.

The sheets are easily put in place by means of aluminum tie rods or bolts, and once erected, not only afford a protection against fire, but, being nonconductors of heat, permit the heating of the building at less cost than if iron siding and roofing were used.

The material is supplied in sheets measuring 27½ inches wide and 4, 5, 6, 7, 8, 9 and 10 feet long.

Material varies in thickness from 3/16″ to 5/16″ and weighs from 2.8 to 3 pounds per square foot.

Ambler Linabestos Wallboard

Wherever a superior flame-proof, fire-resisting wallboard is wanted.

Illustrations Above Show Industrial Houses Covered With Ambler Asbestos Shingles

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JOSEPH T. RYERSON & SON

CHICAGO ST. LOUIS DETROIT BUFFALO NEW YORK

Branch Offices

DENVER HOUSTON JERSEY CITY MILWAUKEE MINNEAPOLIS NEWARK SAN FRANCISCO

IRON – STEEL – MACHINERY

Ryerson Steel-Service

For 80 years the name RYERSON has stood for the immediate shipment of iron and steel products from warehouse stock. Five complete warehouses and plants located in representative industrial centers and in easy reach of the different quarries and mining fields, make it possible for mine owners and operators to secure needed material close at hand and without the delays incident to mill shipments. Iron and steel for construction and maintenance purposes; machinery, machine tools and tool steels for the machine shop; fittings for the boiler room of the power plant—in fact, everything in standard or special steel products can be obtained from Ryerson plants—ready to ship. A few of these products are listed below.

Structurals

Beams for mine timbers, channels, angles, tees, section members for mine construction work, twisted and plain bars for concrete re-enforcement carried in stock lengths and in all sizes. All bars and shapes will be cut to any specified length. Rods will be cut, headed and threaded to order for trussing purposes.

Roofing

Corrugated and V Crimped sheets, both iron and steel, in all sizes and thicknesses, furnished plain, painted or galvanized. Lead-headed nails and galvanized nails with lead washers for laying roofing.

Rivets, Bolts, Etc.

Large stocks in all sizes of machine bolts, carriage bolts, nuts, washers, nails, track bolts and spikes, lag screws, turnbuckles, chain, etc.

Plates and Sheets

Plates, heavy and light, for all kinds of plant and equipment construction. Sheets, iron and steel, plain galvanized or painted, in all sizes and thicknesses. Firmtread Floor Plates and Mason Safety Treads.

Bars and Shapes

Rounds, squares, hexagons, ovals, half ovals, half rounds, flats, cold rolled shafting, etc. Carried in all sizes and standard lengths. Special lengths cut without delay.

Ulster Iron

This is a special grade of refined iron, the product of over 100 years' experience. It is especially adapted for parts subject to vibration and its long fibrous texture and great toughness enable it to resist repeated tensile and twisting stresses. It is extensively used for crane hooks, cold shuts, chains, mine bucket handles, bales, mine car parts, foundation bolts, and for countless other purposes where the highest grade iron is required.

Boiler Fittings

Ryerson plants maintain extensive stocks of boiler fittings, such as flanges, manholes, tubes, tube cleaners and expanders, ferrules, hangers, lugs, braces, dished and flanged heads, rivets, etc. Boiler staybolts made of Ulster Iron are carried in stock in all sizes.

Machinery

Metal working machinery of latest design, including lathes, power drills, milling machines, planers, power hack saws, chain hoists, etc. It pays to install Ryerson equipment in your machine shops. Descriptive literature sent upon request.

Tool Steel

Special tool steels and alloy steels of standard SAE analyses are carried in stock in standard sizes. The Ryerson Special Steel Department will be glad to confer with you on your special requirements.

SEND FOR "THE RYERSON JOURNAL AND STOCK LIST"

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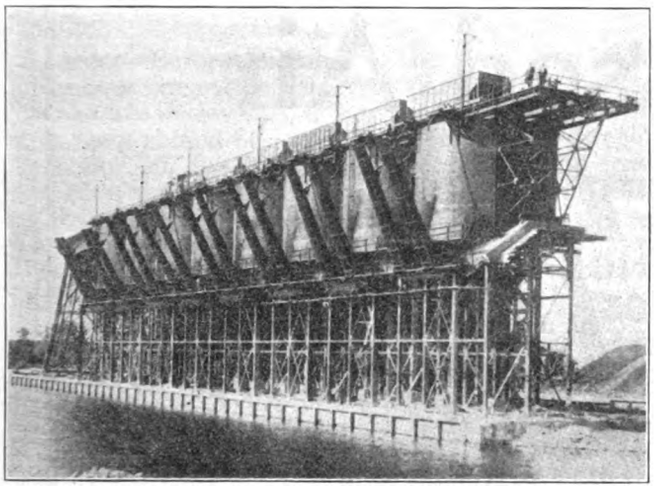
WISCONSIN BRIDGE & IRON CO.

NORTH MILWAUKEE, WIS.

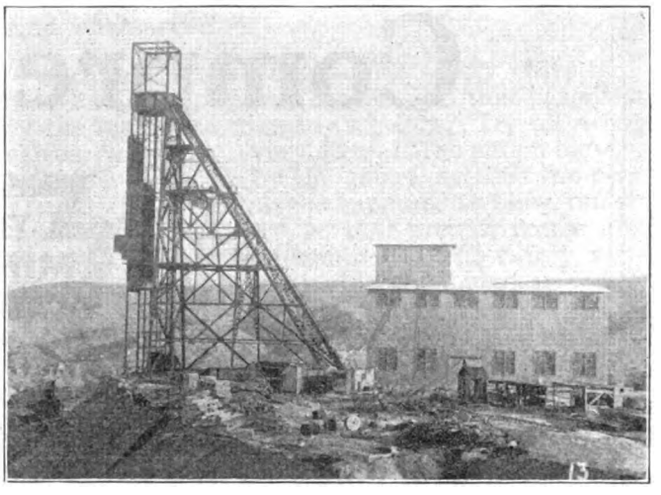
DISTRICT OFFICES

CHICAGO	DETROIT	KANSAS CITY	EL PASO
1619 Monadnock Bldg.	1362 Penobscot Bldg.	206 Commerce Bldg.	709 Caples Bldg.

STEEL CONSTRUCTION



Rock Dock—Michigan Alkali Company.

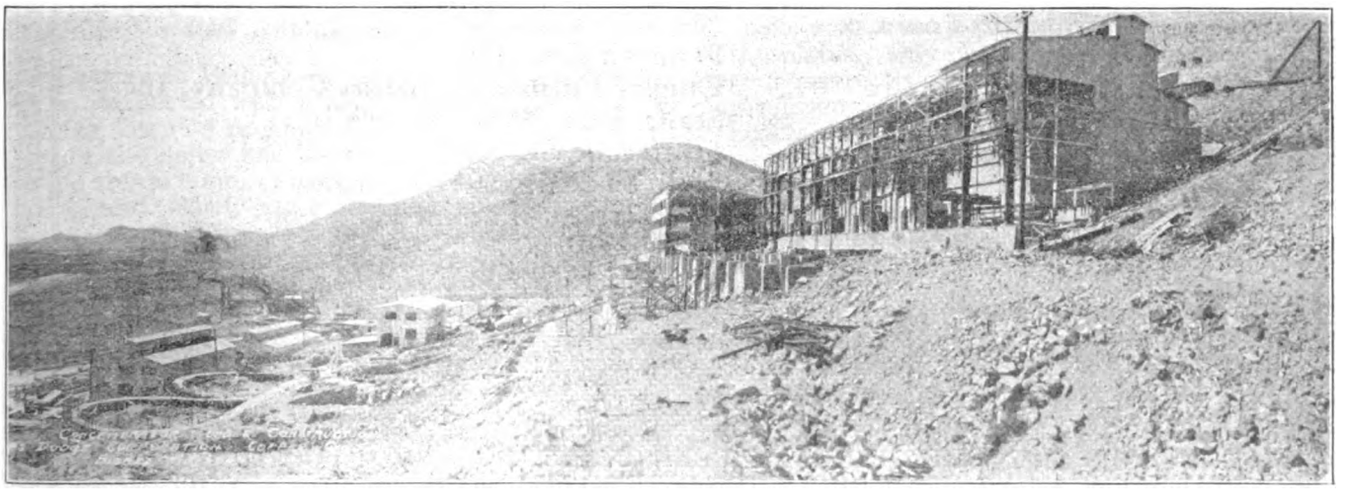


Headframe and Hoist House—Miami Copper Company

We design, fabricate and erect Steel Frame Structures of EVERY DESCRIPTION for Mining and Milling purposes:

Smelter and Furnace Buildings, Crushing Plants, Ore Bins, Concentrators, Sampling Mills, Coal Tipples, Rescreeners, Headframes, Hoist Houses, Pulley Stands, Shop Buildings, Power Houses, Coal Bunkers, Ash Hoppers, Trestles, etc.

We maintain a COMPETENT and EXPERIENCED ENGINEERING FORCE which is at your service at any time for preliminary designs and estimates.



Concentrator Under Construction—Phelps-Dodge Corporation, Warren, Arizona.

DESIGNERS AND CONTRACTORS

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SECTION III

Power Plant and Compressed Air

KEYSTONE
THE MINING CATALOG
CONSOLIDATED PUBLISHING COMPANY INC.

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Allis-Chalmers Mfg. Co.
Brownell Company, The
Buckeye Boiler Skimmer Co., The
Bury Compressor Co.
Celite Products Co.
Chicago Pneumatic Tool Co.
Crane Company
De La Vergne Machine Co.
De Laval Steam Turbine Co.
Dodge Sales & Engineering Co.
Edge Moor Iron Company
Goodrich, B. F. Rubber Co., The
Greene, Tweed & Co.
Ingersoll-Rand Co.
Jenkins Bros.
Kelly & Jones Co., The
McIntosh & Seymour Corp.
Moore Steam Turbine Corporation
Muncie Oil Engine Co.
Nelson Valve Co.
Permutit Co., The
Quigley Furnace Specialties Company, Inc.
Scaife, Wm. B. & Sons Co.
Sturtevant, B. F. Company
Sullivan Machinery Company
Terry Steam Turbine Co., The
Walsh & Weidner Boiler Co., The
Worthington Pump and Machinery Corp.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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Rules for Management and Care of Steam Boilers

As Adopted by the Hartford Steam Boiler Inspection and Insurance Company, by Whose Courtesy This is Published

Water Level—Whenever going on duty in the boiler room, find out, first of all, where the water level is in the boilers. Never unbank nor replenish the fires until this is done. Make sure that the gauge glass and gauge cocks, and all the connections thereto, are free and in good working order. Do not rely upon the glass altogether, but use the gauge cocks also, and try them all, several times a day.

Leaks—Before starting up the fires, open each door about the setting and look carefully for leaks. If leaks are discovered, either then or at any other time, they should be located and repaired; but cool the boiler off, first. If leaking occurs at the fore and aft joints, the insurance company should be notified at once. This is important, whether the attendant considers the leakage serious or not; and it is especially important when the boiler has a single bottom sheet, or is of the two sheet type.

Filling the Boiler—When a boiler has been emptied of water, do not fill it again until it has become cold.

Tight Joints and Good Gaskets—In preparing to get up steam after the boiler has been out of service, be sure that the manhole and handhole joints are tight. Do not use gaskets that are thin and hard.

Getting Up Steam—Vent the boiler in some way, first, to permit the escape of air. Then fill the boiler to the proper level, open the dampers, and start the fires. Start them early, so as to have the pressure up at the required hour, without forcing.

Gas or Oil Fuel—Ventilate the setting thoroughly before lighting the fire. Never turn on the fuel supply when starting up, nor after the snapping out of a burner, without first placing in the furnace a lighted torch or piece of burning waste, to ignite the fuel instantly.

Cutting in Boilers—In firing up a boiler that is to be connected with others that are already in service, keep its stop valve closed until the pressure within the boiler has become exactly equal to that in the steam main. Then open the stop valve a bare crack, and slowly increase the opening until the valve is wide open. The complete operation should occupy two minutes or more. Close the valve at once if there is the slightest evidence of any unusual jar or disturbance about the boiler. See that the steam main to which the boiler is to be connected is thoroughly drained before the valve is opened.

Low Water—In case of low water, immediately cover the fire with ashes or fresh coal. Close the ash-pit doors and leave the fire doors open. If gas or oil is used as fuel, shut off the supply from the burners. Don't turn on the feed under any circumstances, and don't open the safety valve nor tamper with it in any way. Let the steam outlets remain as they are. Get your boiler cool before you do anything else.

Repairs Under Pressure—No repairs of any kind should be made, either to boilers or to piping, while the part upon which the work is to be done is under pressure. This applies to calking, to tightening up bolts under pressure and to repairs of any kind whatsoever.

Care of Safety Valves—The safety valve must not be set at a pressure higher than that permitted by the insurance company's policy. Try all safety valves, cautiously, every day. If the actual blowing pressure, as shown by the gauge, exceeds the pressure at which the valve is supposed to blow, inform the office immediately, so that prompt notice may be sent the insurance company. The safety valve pipe should never have a stop valve upon it.

Routine Use of the Blow-Off—To remove sediment from the bottom of the boiler, open the blow-off valve in the morning, or before the circulation has started up. The valve should be opened wide for a few moments, but it should be opened and closed slowly, so as to avoid shocks from water hammer action. When surface blow-offs are used, they should be opened frequently, for a few minutes at a time.

Foaming—In case of foaming, check the draft and cover the fires with fresh coal, or shut off the burners if oil or gas is used as fuel. Shut the stop valve long enough to find the true level of the water. If this is sufficiently high, blow down some of the water in the boiler, and feed in some fresh. Repeat this several times if necessary. If the foaming does not stop, cool the boiler off, empty it, and find out the cause of the trouble.

Oil in Boilers—Cylinder oil must be kept out of the boilers, because it is likely to cause overheating of the plates. Oily deposits may be removed, in a large measure, by scraping and scrubbing, although more efficient methods of treatment may be required in bad cases. If kerosene is used in a boiler, keep all open lights away from the manhole and handholes, both when applying the kerosene and upon opening the boiler up afterwards; and ventilate the inside of the boiler thoroughly, after oil has been used in it.

Fusible Plugs—Fusible plugs should be filled with pure tin. They should be renewed or refilled as often as may be necessary to keep them in good condition.

Banking the Fires—Clean the fires before banking, push them back against the bridge wall, and cover them well with fresh coal. Keep the ash-pit doors closed, and open the fire doors a crack. Keep the damper nearly closed, but do not close it tight.

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RULES FOR MANAGEMENT AND CARE OF STEAM BOILERS—Continued

Cooling Off—In cooling a boiler before emptying it, first let the fire die out and then close all doors and leave the damper open until the pressure falls to the point at which it is desired to blow. Clean the furnace and let the brickwork cool for at least two hours before opening the blow-off valve. If it is desired to cool the boiler further, after it has been emptied open the manhole and leave everything else as in full actual service—the fire doors, front connection doors and cleaning doors being closed, and the damper and ash-pit doors open.

Emptying the Boiler—First cool the boiler as explained in the last paragraph. Never blow out under a pressure exceeding ten or (at most) fifteen pounds by the gauge.

Removing Deposit and Sediment—The engineer must find out for himself how often his boilers need to be opened and cleaned. In many plants it is necessary to clean every week, while in some favored few it is sufficient to clean every three months. When using kerosene or large amounts of scale solvent, or when (as in the spring time) the water becomes unusually soft, the boilers must be opened oftener than usual. In washing out a boiler, wash the tubes from above, as well as from below.

To Avoid Scalding Men—Never touch any valve whatsoever, in any part of the room, while a man is inside of a boiler, nor even after he has come out again, until he has reported that his work is finished and that he will not enter the boiler again. It is well to lock the stop valve and blow-off valve upon every boiler in which a man is working, while other boilers are under steam. Padlocks and chains may be used for this purpose.

Cleaning the Tubes of Water Tube Boilers—In water tube boilers the covers opposite the three rows of tubes nearest the fire should be taken off once a month and the tubes thoroughly scraped and washed out; and all the tubes should be thoroughly scraped and washed out at least once in four months. This is for water of average quality. If the water is bad, clean the tubes oftener.

Mechanical Tube Cleaners—When mechanical hammers or cleaners are employed for removing scale from tubes, the pressure used to operate them should be as low as will suffice to do the work. Do not allow the cleaner to operate for more than a few seconds upon any one spot, and see that it goes entirely through the tube. Avoid high temperatures in the steam or the water used to operate the cleaner.

Laying Up Boilers—In putting a boiler out of service, it should be cooled, emptied and thoroughly cleaned, both inside and outside. The setting should likewise be cleaned in all its parts. Leave the handhole covers and manhole plates off. After washing the interior of the boiler, let it drain well. Then see that no moisture can collect anywhere about the boiler, nor drip upon it either internally or externally. Empty the siphon below the steam gauge if the boiler room is likely to be cold, or take the gauge off and store it safely away.

Corrosion—Do not allow moisture to come in contact with the outside of the boiler at any time, either from leaky joints or otherwise. Keep the mud drums and nipples and the rear ends of horizontal and inclined tubes in water tube boilers, free from sooty matter. If internal corrosion is discovered, notify your employers at once, so that the insurance company may be promptly informed.

Miscellaneous Suggestions—Examine your boilers carefully in all their parts whenever they are laid off, and keep them as clean as possible, both inside and outside. See that all necessary repairs are made, promptly and thoroughly. Keep the water glass and pressure gauge clean and well lighted. If any contingency arises that you do not understand, report the matter to your employers at once; and if you think it possible that serious trouble may be impending at any time, shut down the boiler immediately.

Local Laws and Ordinances—Inform yourself respecting any local laws or ordinances relating to the duties of engineers and firemen, or to the plant in which you work. If there be any such, attend to them faithfully.

EFFECT OF SCALE IN BOILERS

Take an ordinary granite iron or tinned iron stewpan and firmly glue to its underside a postage stamp. Pour water into the pan and place it on a gas stove so that the postage stamp will be in direct contact with the flame. Leave the pan on the stove until the water has boiled violently and then examine the stamp. The stamp will not even be charred, much less burned. In fact it may be removed from the bottom of the pan and used to post a letter in the regular way. And this, notwithstanding the fact that it was on the underside of the pan and in direct contact with the hottest part of the flame.

Now put into the pan a mixture of water and Portland cement half an inch thick. This, when set, will be the equivalent of half an inch of scale. Repeat the experiment made before and it will be found that the stamp will burn up very quickly.

The reason that the postage stamp on the bottom of the vessel is not charred by the flame when no scale is present is that the water, being in immediate contact with the thin bottom of the vessel, absorbs the heat as fast as it is put into the vessel by the flame. The result is that, no matter how hot the flame may be, the bottom of the vessel remains at practically the same temperature as the boiling water with which it is in contact. In an open vessel the temperature of boiling water, of course, is 212 degrees and this is not sufficiently high to char paper. When scale is present, the water cannot absorb the heat as fast as it is put into the vessel by the flame, as a result of which the temperature becomes greater than 212 degrees and burns the postage stamp.

It is the same with steam-boilers. If the water comes in direct contact with the thin plates, the heat is absorbed, the temperature of the plates remains practically the same as the water, and no harm is done. If there be a considerable thickness of impervious scale in the boiler, the water cannot absorb the heat as fast as it is put into the plates by the furnace, and so the plates become overheated, get red, become plastic, and finally give way to the force of steam pressure, causing a bag, or a rupture, or a violent explosion of the boiler.

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Power Plant Data---Boilers

TUBULAR BOILERS

Each nominal horse power requires:
8 cubic feet total capacity.
2 cubic feet steam room.
10 square feet of heating surface—the whole tube surface being taken as effective.
½ square foot of fire grate surface.
1 cubic foot of water per hour.
10 square inches sectional area of tubes.
13 square inches flue area.
6 square inches chimney area.
Diameter of tubes, 1/30th of their length.

* * * *

For estimating on fire brick work, use the following figures:
1 square foot 4½-inch wall requires 7 brick.
1 square foot 9-inch wall requires 14 brick.
1 square foot 13½-inch wall requires 21 brick.
1 cubic foot brick-work requires 17 nine-inch straight brick.
1 cubic foot fire clay brick-work weighs 150 pounds.
1,000 brick (closely stacked) occupy 56 cubic feet.
1,000 brick (loosely stacked) occupy 72 cubic feet.

* * * *

The effect of scale on the heating surfaces tends to shorten the life of the boiler. That overheating results from scale is certain. To raise steam to a working pressure of 90 pounds the water must be raised to a temperature of 331 degrees F. This may be done through a clean ⅜-inch steel shell by heating the external surface to about 335 degrees. Many scales of only a ¼-inch thickness offer so much resistance to the passage of heat that the heating surfaces must be heated to 700 or 800 degrees Fahrenheit—almost to a red heat. The higher the temperature at which iron is kept the more rapidly it oxidizes, and at any temperature above 600 degrees it soon becomes brittle and granular, from carbonization. This weakens the boiler, and makes expensive repairs necessary.

* * * *

To ascertain heating surface in tubular boilers multiply two-thirds the circumference of boiler by length of boiler in inches and add to it the area of all the tubes.

* * * *

Don't depend too much upon the gauge glass, but try the cocks often enough to keep your hand in in telling the height of water by them.

TABLE GIVING HORSE POWER OF BOILERS

SHELL		TUBES			Heating Surface Square Feet	Horse Power
Diameter (Inches)	Length (Feet)	Number	Length (Feet)	Diameter (Inches)		
72	18	70	18	4	1502	150
72	16	90	16	3½	1472	147
72	16	112	16	3	1496	150
72	15	112	15	3	1400	140
60	18	65	18	3½	1200	120
60	17	65	17	3½	1148	115
60	17	65	17	3½	1148	107
60	16	80	16	3	1088	109
60	15	80	15	3	1020	102
60	14	80	14	3	952	95
60	13	80	13	3	884	88
54	18	50	18	3½	951	95
54	17	50	17	3½	900	90
54	16	50	16	3½	795	79
54	16	60	16	3	832	83
54	15	60	15	3	780	78
54	14	60	14	3	728	73
54	13	60	13	3	676	68
54	12	60	12	3	624	62
48	16	40	16	3½	683	68
48	16	49	16	3	684	68
48	15	49	15	3	642	64
48	14	49	14	3	600	60
48	13	49	13	3	555	55
48	12	49	12	3	513	51
48	11	65	11	2½	542	54
48	10	65	10	2½	495	50
42	15	38	15	3	508	51
42	14	38	14	3	476	48
42	13	38	13	3	441	44
42	12	38	12	3	408	41
42	11	45	11	2½	390	39
42	10	45	10	2½	355	36
42	9	45	9	2½	320	32
42	8	45	8	2½	285	29
42	7	45	7	2½	248	25

FEED-WATER HEATERS

Percentage of Saving for Each Degree of Increase in Temperature of Feed-Water Heated by Waste Steam

Initial Temperature of Feed, Degrees	Pressure of Steam in Boiler, Pounds per Square Inch Above Atmosphere											Initial Temperature, Degrees
	0	20	40	60	80	100	120	140	160	180	200	
32	.0872	.0861	.0855	.0851	.0847	.0844	.0841	.0839	.0837	.0835	.0833	32
40	.0878	.0867	.0861	.0856	.0853	.0850	.0847	.0845	.0843	.0841	.0839	40
50	.0886	.0875	.0868	.0864	.0860	.0857	.0854	.0852	.0850	.0848	.0846	50
60	.0894	.0883	.0876	.0872	.0867	.0864	.0862	.0859	.0856	.0855	.0853	60
70	.0902	.0890	.0884	.0879	.0875	.0872	.0869	.0867	.0864	.0862	.0860	70
80	.0910	.0898	.0891	.0887	.0883	.0879	.0877	.0874	.0872	.0870	.0868	80
90	.0919	.0907	.0900	.0895	.0888	.0887	.0884	.0883	.0879	.0877	.0875	90
100	.0927	.0915	.0908	.0903	.0899	.0895	.0892	.0890	.0887	.0885	.0883	100
110	.0936	.0923	.0916	.0911	.0907	.0903	.0900	.0898	.0895	.0893	.0891	110
120	.0945	.0932	.0925	.0919	.0915	.0911	.0908	.0906	.0903	.0901	.0899	120
130	.0954	.0941	.0934	.0928	.0924	.0920	.0917	.0914	.0912	.0909	.0907	130
140	.0963	.0950	.0943	.0937	.0932	.0929	.0925	.0923	.0920	.0918	.0916	140
150	.0973	.0959	.0951	.0946	.0941	.0937	.0934	.0931	.0929	.0926	.0924	150
160	.0982	.0968	.0961	.0955	.0950	.0946	.0943	.0940	.0937	.0935	.0933	160
170	.0992	.0978	.0970	.0964	.0959	.0955	.0952	.0949	.0946	.0944	.0941	170
180	.1002	.0988	.0981	.0973	.0969	.0965	.0961	.0958	.0955	.0953	.0951	180
190	.1012	.0998	.0989	.0983	.0978	.0974	.0971	.0968	.0964	.0962	.0960	190
200	.1022	.1008	.0999	.0993	.0988	.0984	.0980	.0977	.0974	.0972	.0969	200
210	.1033	.1018	.1009	.1003	.0998	.0994	.0990	.0987	.0984	.0981	.0979	210
220	.....	.1029	.1019	.1013	.1008	.1004	4.1000	.0997	.0994	.0991	.0989	220
230	.....	.1039	.1031	.1024	.1018	.1012	.1010	.1007	.1003	.1001	.0999	230
240	.....	.1050	.1041	.1034	.1029	.1024	.1020	.1017	.1014	.1011	.1009	240
250	.....	.1062	.1052	.1045	.1040	.1035	.1031	.1027	.1025	.1022	.1019	250

This table taken from Kent furnishes a ready and accurate means of determining the percentage of the gain obtained by heating feed water.

BOILER HORSE POWER

The accepted rule for figuring horse power is as follows:

One horse power equals the evaporation of 30 lbs. of water per hour from an initial temperature of 100 deg. Fahr. into steam at 70 lbs. gauge pressure, or its equivalent; 34½ lbs. of water evaporated per hour from a temperature of 212 deg. Fahr. into steam at 212 deg.

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Power Plant Data---Boilers, Steam, Piping

QUANTITY OF FEED WATER REQUIRED TO SUPPLY BOILER

Horse-Power of Boiler	Quantity of Feed Water Required		Temperature of Feed Water. Degrees Fahr.
	Gallons per Minute	Pounds per Hour	
50	3.60 to 4.20	1599 to 2029	100 to 212
100	6.57 to 7.63	3285 to 3815	100 to 212
200	13.14 to 15.26	6590 to 7630	100 to 212
250	16.43 to 19.07	8215 to 9535	100 to 212
300	19.71 to 22.89	9855 to 11445	100 to 212
400	26.28 to 30.52	13140 to 15260	100 to 212
500	32.85 to 38.15	16425 to 19075	100 to 212
600	39.42 to 45.78	19710 to 22890	100 to 212
800	52.26 to 61.04	26280 to 30520	100 to 212
1000	65.70 to 76.30	32850 to 38150	100 to 212
1200	78.84 to 91.56	39420 to 45780	100 to 212
1500	98.55 to 114.45	49275 to 57225	100 to 212
1800	118.26 to 137.34	59130 to 68670	100 to 212
2200	144.50 to 167.80	71290 to 83930	100 to 212
3000	197.10 to 228.90	98500 to 114500	100 to 212
3500	229.95 to 267.05	114975 to 133525	100t o 212
4500	295.65 to 343.35	147825 to 171675	100 to 212
6000	394.20 to 457.80	197100 to 228900	100 to 212
7000	459.90 to 534.10	229950 to 267050	100 to 212

TABLE SHOWING COST OF EVAPORATING 1000 POUNDS OF WATER, WITH DIFFERENT GRADES OF FUEL AND VARYING EVAPORATIONS

Actual Evaporation per Pound Fuel	PRICE OF COAL PER TON									
	$0.75	$1.00	$1.25	$1.50	$1.75	$2.00	$2.50	$3.00	$3.50	$4.00
	COST OF EVAPORATING 1,000 LBS. OF WATER									
5. lbs....	.0750	.1000	.1250	.1500	.1750	.2000	.2500	.3000	.3500	.4000
5.5 lbs....	.0681	.0909	.1136	.1363	.1591	.1818	.2272	.2727	.3182	.3636
6. lbs....	.0625	.0833	.1041	.1250	.1458	.1666	.2082	.2500	.2916	.3333
6.5 lbs....	.0577	.0769	.0961	.1154	.1349	.1538	.1923	.2307	.2692	.3077
7. lbs....	.0535	.0714	.0892	.1071	.1250	.1428	.1785	.2143	.2500	.2857
7.5 lbs....	.0500	.0666	.0833	.1000	.1166	.1333	.1666	.2000	.2333	.2666
8. lbs....	.0469	.0625	.0781	.0937	.1093	.1250	.1562	.1875	.2187	.2500
8.5 lbs....	.0441	.0588	.0735	.0882	.1029	.1176	.1470	.1764	.2059	.2353
9. lbs....	.0416	.0555	.0694	.0833	.0972	.1111	.1389	.1666	.1944	.2222
9.5 lbs....	.0394	.0526	.0657	.0789	.0921	.1052	.1316	.1578	.1842	.2105
10. lbs....	.0375	.0500	.0625	.0750	.0875	.1000	.1250	.1500	.1750	.2000
10.5 lbs....	.0357	.0476	.0595	.0714	.0833	.0952	.1190	.1428	.1666	.1994
11. lbs....	.0340	.0454	.0568	.0681	.0795	.0909	.1136	.1363	.1590	.1818

PROPERTIES OF SUPERHEATED STEAM

Boiler Pressure Pounds per Square Inch	Superheat Degrees F	Temperature of Steam Degrees F	Total Heat B.T.U.'s per Pound	Specific Volume Cubic Feet per Pound	Increase in Volume over Sat. Steam Per Cent.
150	25	390.9	1210.6	2.87	4.4
	50	415.9	1225.2	2.99	8.7
	75	440.9	1238.8	3.10	12.7
	100	465.9	1252.0	3.21	16.7
	150	515.9	1277.6	3.43	24.7
	200	565.9	1302.5	3.64	32.4
160	25	395.8	1211.8	2.72	4.5
	50	420.7	1226.6	2.83	8.9
	75	445.7	1240.8	2.93	12.6
	100	470.7	1253.6	3.04	16.9
	150	520.7	1279.1	3.24	24.6
	200	570.7	1304.1	3.44	32.3
170	25	400.3	1213.0	2.58	4.4
	50	425.3	1227.9	2.68	8.5
	75	450.3	1241.7	2.78	12.5
	100	475.3	1255.0	2.89	17.0
	150	525.3	1280.6	3.08	24.8
	200	575.3	1305.6	3.27	32.4
180	25	404.6	1214.2	2.45	4.3
	50	429.6	1229.2	2.55	8.5
	75	454.6	1243.1	2.65	12.8
	100	479.6	1256.4	2.75	17.0
	150	529.6	1282.0	2.93	24.7
	200	579.6	1307.0	3.11	32.3
190	25	408.8	1215.2	2.34	4.4
	50	433.8	1230.4	2.44	8.9
	75	458.8	1244.4	2.53	13.0
	100	483.8	1257.7	2.62	17.0
	150	533.8	1283.3	2.80	25.0
	200	583.8	1308.3	2.97	32.7
200	25	412.9	1216.3	2.23	4.3
	50	437.9	1231.6	2.33	8.9
	75	462.9	1245.6	2.42	13.1
	100	487.9	1259.0	2.51	17.3
	150	537.9	1284.6	2.68	25.2
	200	587.9	1309.7	2.84	32.7

From Tables by Marks and Davis

EXPANSION OF STEAM PIPES

The linear expansion and contraction of pipe, due to differences of temperature of the fluid carried and the surrounding air must be cared for by suitable expansion joints or bends.

In order to determine the amount of expansion or contraction in a pipe line, we give below a table showing the increase in length of a pipe 100 feet long at various temperatures.

The expansion for any length of pipe may be found by taking the difference in increased length at the minimum and maximum temperature, dividing by 100 and multiplying by the length of the line under consideration.

EXPANSION OF PIPE
Increase in Length—Inches Per 100 Feet

Temperature, Degrees F.	Steel	Wrought Iron	Cast Iron	Brass and Copper
0	0	0	0	0
20	.15	.15	.10	.25
40	.30	.30	.25	.45
60	.45	.45	.40	.65
80	.60	.60	.55	.90
100	.75	.80	.70	1.15
20	.90	.95	.85	1.40
40	1.10	1.15	1.00	1.65
60	1.25	1.35	1.15	1.90
80	1.45	1.50	1.30	2.15
200	1.60	1.65	1.50	2.40
20	1.80	1.85	1.65	2.65
40	2.00	2.05	1.80	2.90
60	2.15	2.20	1.95	3.15
80	2.35	2.40	2.15	3.45
300	2.50	2.60	2.35	3.75
20	2.70	2.80	2.50	4.05
40	2.90	3.05	2.70	4.35
60	3.05	3.25	2.90	4.65
80	3.25	3.45	3.10	4.95
400	3.45	3.65	3.30	5.25
20	3.70	3.90	3.50	5.60
40	3.95	4.20	3.75	5.95
60	4.20	4.45	4.00	6.30
80	4.45	4.70	4.25	6.65
500	4.70	4.90	4.45	7.05
20	4.95	5.15	4.70	7.45
40	5.20	5.40	4.95	7.85
60	5.45	5.70	5.20	8.25
80	5.70	6.00	5.45	8.65
600	6.00	6.25	5.70	9.05
20	6.30	6.55	5.95	9.50
40	6.55	6.85	6.25	9.95
60	6.90	7.20	6.55	10.40
80	7.20	7.50	6.85	10.95
700	7.50	7.85	7.15	11.40
20	7.80	8.20	7.45	11.90
40	8.20	8.55	7.80	12.40
60	8.55	8.90	8.15	12.95
80	8.95	9.30	8.50	13.50
800	9.30	9.75	8.90	14.10

From Crane Co. Catalog

PROPERTIES OF SATURATED STEAM
(Peabody)

Pressure by Gauge. Lbs. per Sq. In.	Temperature of Steam. Degrees Fahr.	Total Heat of Steam in B.T.U. above Water at 32° Fahr.	Weight of Steam. Pounds per Cubic Foot	Relative Volume. Water at 39° F. = 1
0.	212.0	1146.6	.0379	1646.0
5.3	227.9	1151.6	.0507	1231.0
15.3	250.2	1158.3	.0742	841.3
25.3	267.1	1163.4	.0972	642.0
35.3	280.9	1167.6	.1198	520.5
45.3	292.5	1171.2	.1422	438.5
55.3	302.7	1174.3	.1643	379.3
65.3	311.8	1177.0	.1862	334.5
75.3	320.0	1179.6	.2080	299.4
85.3	327.6	1181.8	.2296	271.1
100.3	337.8	1185.0	.2617	237.6
105.3	341.0	1185.9	.2724	228.3
110.3	344.1	1186.9	.2830	219.6
115.3	347.1	1187.8	.2936	211.6
120.3	350.0	1188.7	.3042	204.2
125.3	352.8	1189.5	.3147	197.3
130.3	355.5	1190.4	.3253	190.9
135.3	358.2	1191.2	.3358	184.9
140.3	360.7	1192.0	.3463	179.2
145.3	363.3	1192.7	.3567	173.9
150.3	365.7	1193.5	.3671	169.0
155.3	368.2	1194.2	.3775	164.3
160.3	370.5	1194.9	.3879	159.8
165.3	372.8	1195.7	.3983	155.6
170.3	375.1	1196.3	.4087	151.6
175.3	377.3	1197.0	.4191	147.8
180.3	379.5	1197.7	.4296	144.2
185.3	381.6	1198.3	.4400	140.8
190.3	383.7	1199.0	.4503	137.5
195.3	385.7	1199.6	.4605	134.5
200.3	387.7	1200.2	.4707	131.5

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PIPING SYSTEM

The factors which should receive the most careful consideration in the design of the piping system are: the size of pipe to be employed, the methods used in reducing and disposing of condensation, and the means used in keeping the radiation losses at a minimum.

The consensus of engineering opinion on the question of material of pipes and fittings indicates that all pipe should be wrought iron, soft steel or cast iron. Pipe at present is made in three different weights, "standard", "extra strong" and "double extra strong", and the sizes, unless otherwise stated, are given in terms of the inside diameter. However, the difficulty in flanging wrought iron pipe has in some measure limited its use to plants which are located near where the pipe is manufactured.

The following are the standard specifications for power piping adopted by the Power Piping Society, June 24, 1917:

General Requirements

In the absence of a distinct specification by the Purchaser for material of a better grade, all material furnished shall conform to these specifications.

It is the intention that all material furnished hereunder shall be of the quality and weight which experience has shown to be safe and economical, hence the pressures specified are somewhat under those at which satisfactory service can be expected under favorable conditions, but as high as good practice will permit.

In the event of a specification by the Purchaser for service more severe for a given class of material than that given herein such material shall be furnished at the Purchaser's risk, and any guarantees for such material made hereunder become null and void.

VALVES

Materials

Castings: All castings shall be smooth and free from injurious defects.

Cast Steel: The metal in steel castings shall conform to the requirements of the American Society for Testing Materials for "Medium Castings."

Semi-Steel: The metal in semi-steel castings shall have a tensile strength of not less than 30,000 pounds per square inch. A transverse test of the "Arbitration Bar," as outlined by the American Society for Testing Materials, supported 12 inches between centers shall show before breaking a load of 3,300 pounds and a deflection of not less than .12 inches.

Gray Iron: The metal in gray iron castings shall have a tensile strength of not less than 20,000 pounds per square inch. A transverse test as for Semi-Steel shall show before breaking a load of 2,900 pounds and a deflection of .10 inches.

Dimensions of Flanged Fittings

All standard and extra heavy flanged fittings shall conform to the center to face, thickness, and flange dimensions of the "American Standard," as recommended in 1914 by the A. S. M. E. Fittings used for working steam pressures 25 pounds and lower, and for water pressures 50 pounds and lower, may be lighter in the shell than the American Standard for 125 pounds working pressure.

Drilling and Facing of Flanges

All drilling of flanges shall conform to the templates of the said "American Standard," and shall straddle centers.

Standard flanges shall be plain faced. Extra heavy flanges shall have raised face extending to the inside edge of bolt holes.

Spotfacing and Backfacing

Flanges of Extra heavy Cast Iron or Semi-Steel material shall be either spotfaced or backfaced for all sizes 14 inch and larger. All Cast Steel flanges shall be spotfaced or backfaced.

Type of Joints

The following sizes are the smallest for which flanged joints will be required except for unions. Below these sizes screwed connections may be used.

Superheated Steam	2 inches
Saturated steam above 125 pounds	2½ inches
Boiler Feed	2½ inches
Exhaust	2½ inches
Low Pressure Water	2½ inches
Blow-Off	2 inches
Drains	2½ inches

Valves, next to the boilers and engines themselves, are the most important items used in the steam operating plant. In years gone by little or no attention was paid to this feature and operating engineers were more or less satisfied with practically any kind of a valve provided it would open or close the line. Now valves have become as much a scientific study as the boiler, the engine, the condenser and the feed water heater. Laws have been passed which make it necessary to install valves of a reliable make, along with safety devices for the protection of both life and property.

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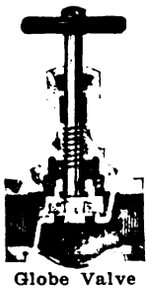
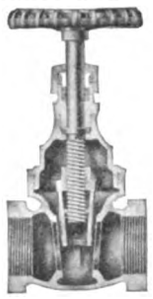
One of the most common type of valve is the **Globe Valve.**


Globe Valve

It should be set so the pressure will be on the underside of the disc, for if set in the opposite manner, should the disc become detached, it could not be opened, even though the stem did move. This type of valve causes considerable friction as the flow must make two turns at nearly right angles and should be used only for throttling, for blow off purposes or for sizes smaller than ¾ inch.

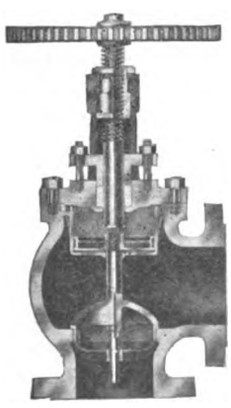
The **Gate Valve,** or straightway type, as it is sometimes called, offers but little resistance and is the commonly used valve about steam plants. This valve is made with both inside and outside screw, the latter being preferable where space permits owing to the fact that the stem travels and the position of the disc can be determined at a glance. All outside screw gate valves should be back-seated to provide for repacking under pressure. Both types can be furnished in the taper wedge and parallel seat type.


Gate Valve

Check Valves should be installed where it is essential that the flow should always be in the same direction. There are several different styles of this valve, the swing, the ball lift and the internal dash-pot. The swing type as a rule is generally preferred as it is practically a straightway valve and offers no resistance to the flow. Its seat and disc are inclined at an angle, this allowing but a small chance for sediment to gather in either.

The **Safety Valve** can be furnished in either the globe or angle type and is used for reducing pressure when it exceeds a certain point. This valve is made in several different styles but in all cases the principle of operation is the same, consisting of a valve opening and being held in position by a spring or weight.

The Non-Return Valve is according to general practice placed on each boiler lead for the following reasons:


Angle Pattern Non-Return Valve

1. It instantly and automatically isolates a boiler from the header, in the event of a tube blowing out or an elbow bursting, or if the pressure in the boiler is reduced suddenly from any cause.

2. It acts as a safety stop to prevent steam being turned on into a cold boiler while men are working inside, as it can not be opened where there is pressure on the header side only.

3. When placed between the boiler and the header it acts as an equalizing valve between the different units of the battery, remaining closed as long as the boiler pressure is lower than that in the header.

Non-Return Valves should work quietly and be installed in the pipe line with its stem in a vertical position, and so that the boiler pressure enters underneath the disc.

For Superheated Steam they shall be extra heavy, cast steel completely monel mounted, with monel metal pistons and dash pots if same are internal, and monel metal stems.

For Saturated Steam up to 250 pounds per square inch they shall be semi-steel, completely bronze mounted, with bronze pistons and dash pots and bronze stems.

Back pressure valves, exhaust relief valves, reducing valves, throttle valves and valves of a special nature should be discussed with engineers or experts who are familiar with these lines. When in doubt as to the service a certain type of valve will perform it is always advisable to consult some authority on valves, for with all justice to the manufacturer, no one valve will answer all purposes and quite often a valve is condemned, not on account of its quality, but because it is not adapted to its requisite function.

Material and test pressures for the various services shall be as follows:

Superheated Steam: Gate valves 2 inches and larger shall be extra heavy, outside screw and yoke pattern, with cast steel bodies, bonnets, discs and yokes; monel metal or 23 per cent nickel steel seats and disc rings; monel metal or 23 per cent nickel steel stems; and monel metal or 23 per cent nickel steel back-seating bushing below the stuffing box. Valves 8 inches and larger shall be by-passed.

Globe and angle valves 2 inches and larger shall conform to the same general specification.

All stop valves 1½ inches and smaller shall be extra heavy and shall be made of bronze containing not less than 10 per cent of nickel.

Valves shall be tested to 800 pounds hydrostatic pressure.

Saturated Steam Between 150 Pounds and 250 Pounds Per Square Inch Inclusive: Gate valves 2½inches and larger shall be extra heavy, outside screw and yoke pattern, with semi-steel bodies, bonnets, discs and yokes; bronze seats and disc rings; and bronze stems. Gate valves 8 inches and larger shall be by-passed.

Globe and angle valves 2½ inches and larger shall conform to the same general specification.

All valves 2 inches and smaller shall be extra heavy bronze.

Valves shall be tested to 800 pounds hydrostatic pressure.

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Saturated Steam Between 125 Pounds and 149 Pounds Per Square Inch Inclusive: Gate valves 2½ inches and larger shall be medium, outside screw and yoke pattern, tested to 500 pounds hydrostatic pressure, with gray iron bodies, bonnets, discs and yokes; bronze seats and disc rings; and bronze stems.

Gate valves 10 inches and larger shall be by-passed.

Globe and angle valves 2½ inches and larger shall be extra heavy pattern, tested to 800 pound hydrostatic pressure, but other wise to the same general specification.

All valves 2 inches and smaller shall be extra heavy bronze, tested to 500 pounds hydrostatic pressure.

Boiler Feed Between 125 Pounds and 250 Pounds Per Square Inch Inclusive: Gate valves 2½ inches and larger shall be extra heavy, outside screw and yoke pattern, with semi-steel bodies, bonnets, discs and yokes; bronze seats and disc rings and bronze stems.

Globe and angle valves 2½ inches and larger shall conform to the same general specification.

Check valves 2½ inches and larger shall be extra heavy pattern, with bronze seats and disc rings.

All valves 2 inches and smaller shall be extra heavy bronze.

Valves shall be tested to 800 pounds hydrostratic pressure.

Exhaust: Gate valves 14 inches and larger shall be outside screw and yoke, low pressure pattern, suitable for 25 pounds working steam pressure, with gray iron bodies, bonnets, discs and yokes; bronze seats and disc rings; and rolled steel stems. Where space does not permit using outside screw and yoke, inside screw patterns may be used.

Gate valves 2½ inches to 12 inches inclusive. shall be standard pattern, outside screw and yoke. suitable for 125 pounds working pressure, with gray iron bodies, bonnets, discs and yokes; bronze seats and disc rings; and rolled steel stems.

Gate valves 2 inches and smaller shall be standard brass.

Suction and Low Pressure Water: Gate valves shall conform to the same specification as for **"Exhaust"** except that in every case bronze stems shall be used.

Check valves shall be standard pattern swing checks with bronze seats and disc rings.

Blow-Off: Blow-off connections shall be double valved.

Drains Between 125 Pounds and 250 Pounds Per Square Inch: Valves shall conform to the specification for those for "Saturated Steam between 150 and 250 pounds per square inch inclusive."

Low Pressure Drains: Valves shall conform to the specifications for those for **"Exhaust."**

Fittings

Superheated Steam: Fittings 2 inches and larger shall be extra heavy, cast steel. Fittings 1½ inches and smaller shall be forged or cast steel.

Saturated Steam, Boiler Feed and Drains Between 125 Pounds and 250 Pounds Per Square Inch, Inclusive: Fittings 2½ inches and larger shall be extra heavy, semi-steel. Elbows for boiler feed shall be long radius where possible. Fittings 2 inches and smaller shall be extra heavy, gray iron.

Exhaust, Suction, Low Pressure Water and Low Pressure Drains: Fittings 14 inches and larger shall be low pressure, gray iron, suitable for 25 pounds working steam pressure. Fittings 12 inches and smaller shall be standard cast iron.

Flanged elbows for water shall be long radius where possible.

Blow-Off: Fittings shall be extra heavy semi-steel. Long radius fittings shall be used where possible.

Pipe, Flanges and Unions

Van Stone flanges shall fit the pipe closely. The lap shall be finished off to the inside edge of the bolt holes and faced with a fine tool finish.

Screw flanges shall be made up by machine where possible and all extra heavy flanges made up in the shop shall be refaced.

Steel flanges shall correspond in thickness to the flange of the American Standard for Fittings.

Superheated Steam: Flanges 6 inches and larger shall be high hub steel, Van Stoned. Flanges 5 inches and smaller shall be steel, screwed.

Saturated Steam Between 150 Pounds and 250 Pounds Inclusive: Flanges 6 inches and larger shall be low hub steel, Van Stoned.

Flanges 5 inches and smaller shall be extra heavy semi-steel, screwed.

Saturated Steam Between 125 Pounds and 149 Pounds Per Square Inch Inclusive: Flanges 14 inches and larger shall be extra heavy high hub semi-steel, Van Stoned.

Flanges 12 inches and smaller shall be extra heavy semi-steel, screwed.

Boiler Feed and Drain Piping Between 125 Pounds and 250 Pounds Per Square Inch Inclusive: Flanges shall be extra heavy semi-steel, screwed.

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Exhaust, Suction, Low Pressure Water and Low Pressure Drains: Flanges 14 inches and larger shall be standard cast iron pattern, Van Stoned.

Flanges 12 inches and smaller shall be standard cast iron, screwed.

Blow-Off: Flanges shall be extra heavy semi-steel, screwed.

Unions: On all screwed work a sufficient number of unions shall be used to facilitate repairs. One union shall be used near each screwed valve. Unions 1½ inches and larger shall be flanged and below 1½ inches they shall be gasketless, with non-corrosive seats.

Wrought Pipe

Wrought pipe shall be steel. Standard pipe shall be buttwelded for sizes 3 inches and smaller and lapwelded for sizes 3½ inches and larger. Extra strong pipe shall be buttwelded for sizes 2 inches and smaller and lapwelded for sizes 2½ inches and larger.

Steam Between 150 Pounds and 250 Pounds Per Square Inch Inclusive: Pipe shall be full weight 7 inches and smaller. Sizes larger than 7 inch shall be of the following thickness or weights per foot: 8 inch, 28.55 pounds; 9 inch, 33.90 pounds; 10 inch, 40.48 pounds; 12 inch, 49.56 pounds; 14 to 20 inch, inclusive, ⅜ inches; 22 to 24 inch, inclusive, 7/16 inches.

Steam Between 125 Pounds and 149 Pounds Per Square Inch Inclusive; Suction and Low Pressure Water: Pipe shall be full weight 7 inches and smaller. Sizes larger than 7 inch shall be of the following thickness or weights per foot: 8 inch, 24.69 pounds; 9 inch, 33.90 pounds; 10 inch, 34.24 pounds; 12 inch, 43.77 pounds; 14 to 20 inch inclusive, 5/16 inches; 22 inch to 24 inch inclusive, ⅜ inches.

Boiler Feed: Pipe for pressure between 150 and 250 pounds per square inch inclusive shall be extra strong and between 125 pounds and 149 pounds per square inch inclusive, shall conform to the specifications for "Steam" for the same pressures.

Exhaust Piping: Pipe 7 inches and smaller shall be full weight; 8 inch to 12 inch inclusive, shall be the same as for "Steam" between 125 pounds and 149 pounds inclusive; between 14 inches and 18 inches inclusive it shall be ¼ inch; and between 20 inches and larger it shall be of the lightest card weight.

Blow-Off: Pipe shall be extra strong.

Drains: Pipe shall conform to the specification for Steam Piping for the same pressure and service.

Welding: Where it is advisable economically, branches shall be welded to main piping, in preference to the use of fittings. All welds so made shall receive a hammer test under hydrostatic pressure three times the working pressure. The fillets and branches if buttwelded shall be built up to a radius equal to not less than three times the thickness of the pipe wall.

Bends: Bends shall be used for changes of alignment in preference to fittings. They shall be substantially round in section and free from injurious buckles. Radii equal to not less than 6 diameters of the pipe shall be used where possible.

Cast Iron Pipe

Where used for exhaust, suction, and low pressure water, Cast Iron pipe shall correspond in thickness to "Class A" pipe as specified by the American Water Works Association.

Bolts

All flange bolts 1½ inches in diameter and smaller shall have square heads and U. S. Standard hexagonal cold punched chamfered and trimmed nuts. For bolts larger than 1½ inches studs with two nuts may be used. When pulled up the bolt thread shall extend completely through the nut.

Gaskets

Gaskets shall fit inside of bolt holes for all lines not under vacuum. Vacuum lines shall have full faced gaskets.

Sheet Gaskets up to and including 12 inch size shall be 1/16 inch thick and for 14 inch and larger they shall be 3/32 inches thick.

Superheated Steam: Gaskets shall be superheated sheet or metal.

Saturated Steam; Boiler-Feed, Blow-Off and Drains: Gasket shall be Rainbow or equivalent, or corrugated copper.

Exhaust: Gaskets shall be Rainbow or equivalent.

Suction and Low Pressure Water: Gaskets shall be cloth inserted rubber or equal.

Supports

A sufficient number of supports, preferably hangers, shall be provided and so placed that their working stresses shall have a factor of safety of not less than six, assuming that each hanger is bearing its proportion of the load with the line full of water.

Sufficient anchorage shall be provided where necessary.

If roller supports are used they shall have screw adjustment.

Piping Not Shown

Piping and appurtenances such as drains, traps, priming pipes, gage and oil piping, etc., called for but not shown on drawings shall be furnished up to a value of $..... for material only at prevailing market prices. Any lines ordered in excess of this amount shall be considered as extra work and shall be furnished at prices to be agreed upon between the Purchaser and the Company.

Size of Steam Lines

The factors which govern the size of steam lines are: the allowable steam velocity and the radiation loss. Radiation increases with the size of pipe, while the velocity of steam decreases; however, in

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modern practice there is a tendency toward the higher velocity, and 15,000 feet per minute is not unusual with superheated steam; formerly 6,000 feet per minute was considered the limit.

In "Power," June 19, 1915, Mr. F. A. Salmon presents the following formula as representing standard practice in determining the size of pipe:

$$d^2 = \frac{w}{k}$$

Where:

d=pipe diameter.
a=area of bore.
w=a×C=pounds of steam per hour.
C=a constant.

$$K = \frac{3.1416 \times C}{4}$$

VALUES OF K AND C.

Vacuum Hg. in inches	28	26	24	22	20	18	16	6	0
C	50	84	105	122	134	144	151	176	187
K	39.2	66	82.5	95.7	102	113	118.6	138	147
Gauge Pressure	80	100	125	150	175	200			
C	267	275	284	291	298	304			
K	210	216	223	229	234	239			

* * * *

Properly constructed feed water heaters will save from 10 to 15 per cent. of fuel.

Steam engines, in economy, vary from 14 to 80 lbs. of feed water and from 1½ to 7 lbs. of coal per hour for every indicated horse power. Condensing engines require from 20 to 30 gallons of water at an average low temperature to condense the steam represented by every gallon of water evaporated in the boilers supplying the engines.

To calculate the horse power of boilers, the Centennial standard is now generally accepted. An evaporation of 30 pounds of water per hour from a feed temperature of 100 degrees, Fahr., into steam of 70 pounds gauge pressure, and may be considered equal to 34½ pounds of water from and at 212 degrees, Fahr., or 33,305 B. T. U. per hour.

SPECIMEN FORM SHEET FOR ENGINES

(Information Desired by Manufacturers)

For what service will engine be required?.....
.....
State the kind wanted.....
.....
What indicated horse-power will the engine be ordinarily required to develop?.....
Will engine run condensing or non-condensing?.....
What steam pressure (by gauge) will be carried by boilers?
.....
About what will be the distance from the engine to the boiler?
.....
Is speed of engine determined, if so, what speed is required?
.....
State if engine is to receive a belt, or rope drive, or direct connection to line shaft.....
State if engine is to be belted, forward or back.....
State which direction engine is to run, over or under.....
Standing at the cylinder, looking towards crankshaft, will the crankshaft be right or left?.....
State size of driving pulley wanted.....
Remarks .....
.....

SPECIMEN FORM SHEET FOR BOILERS

(Information Desired by Manufacturers)

State kind wanted.....

State number of horse-power required.....

What type and power of engines are to be supplied with steam from these boilers .....

Will steam be used for any other purpose; if so, how much?
.....

What steam pressure (by gauge) is it desired to carry?.....
.....

Will one stack be used for all boilers; or a separate stack for each? .....

What kind of fuel will be used?.....

Do you want a water heater? .....

Do you want a feed water pump? .....

Do you wish injectors? .....

What accessories are desired for the plant?.....
.....
.....

Do transportation facilities impose a limit on weight or size?
.....

Remarks .....

SPECIMEN FORM SHEET FOR ELECTRIC POWER

(Information Desired by Manufacturers)

Is the pant to be driven by direct connection, belt, gearing, or rope transmission?.....

Are we to furnish generator or motor; if so, what make is preferred? .....

Shall we use our own judgment in making selection?.....
.....

Do you prefer alternating or direct current machines?.....

What power will be used for driving the same?.....

If lights are wanted, will current be taken from the same circuit? .....

What will be the distance of motor from generator?.....

Do you want an inclosed or regular motor?.....

Will the motor be placed in a wet or damp location?.....

Are transformers wanted; if so, state primary voltage.....
.....secondary .....

Is an automatic starting device wanted?.....

Shall we furnish all wires, etc?.....

In addition to the instruments necessary for starting and stopping, what other equipment is desired?.....
.....

What kind and make of generator have you, or what do you intend to install?.....
.....

What is the voltage?.....

What will be the voltage at the motor?.....

What will be the effective horse-power at motor?.....

What is the working speed of motor?.....

What is the size of driving pulley?.....

If alternating, state number of cycles.....Phase.....
Voltage .....

Remarks .....
.....

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SPECIMEN FORM SHEET FOR WATER WHEELS

(Information Desired by Manufacturers)

What is the quantity of water available, in cubic feet, gallons or Miner's inches per minute?.....

If water is not constant at all seasons give maximum..... and minimum.....flow.

Is it desired to have the wheel use the maximum water supply? .....

What is the head or vertical fall from ditch, flume or other source of supply, to the point where the wheel is to be located? .....

Horse-power required; maximum.....minimum.....

Is future increase of power desired?.....

If any other machinery is to be driven, so state.....
.....

If for driving dynamo, give capacity and speed.....
.....

Is it for power, transmission, or lighting purposes?.....
.....

What is the size of pulley to be driven by pulley on water-wheel shaft? .....

What length of pipe is necessary to conduct the water to the wheel? .....

If pipe is installed, what is the diameter of the same?....
.....

If the pipe is of several sizes, give length of each size.....
.....

What is the size of the flume?.....

State the velocity of flow.....or grade on which flume is built.....

If the carrying capacity is known, state it.....

If the wheel is installed, what is the effective horse-power?
.....

What make is the wheel?.....

Is the wheel on a horizontal or vertical shaft?.....

What is the number of revolutions per minute?.....

What is the diameter of the shaft?.....What is the diameter of the pulley?.....Face of same?.....

NOTE—Do not give as the water supply, the amount that will fill a certain size of pipe—it is unreliable.

It is advisable to furnish, if possible, a profile of the pipe line showing the pressure at different points, so as to divide the line up into thicknesses proportionate to the pressures, especially if it is of extreme length and will be under a heavy pressure; this data is very essential in order to lay it out economically.

Remarks .....
.....
.....

ELECTRIC AND TRANSMISSION LINES

While metal and concrete poles and steel towers may be used for the more important transmission lines, the wood pole construction still has a wide field of application, especially where the transmission lines pass through country in which suitable pole timber grows. Therefore, in considering the transmission of power throughout coal mining districts, it will here be assumed that the wooden pole offers the more convenient type of construction, and very little reference will be made to steel towers.

Selection of Poles

Cedar and chestnut are most commonly used for pole timbers. These are selected from sound, mature, well-grown trees, which are cut while the sap is down (during the winter months), and preferably seasoned for several months before being placed in the lines. Experience indicates that young wood is more apt to decay than the wood of older timber, owing to its large content of aluminate in which destructive fungi flourish.

The item of seasoning may amount to as much as two or three years in the life of the pole, and for best results all poles should be stripped of bark and then seasoned under cover for several months until thoroughly dry.

There are many methods of treating timbers which are constantly exposed to the weather and ground, but owing to the comparatively late introduction of these processes their relative merit is not yet fully determined. Some of these treatments are: Creosoting, Kyanizing, Burnetizing and Vulcanizing, all of which tend to retard decay by either extracting the natural sap and forcing into the wood a preservation compound, or by simply neutralizing the sap. These treatments have as yet not come into extensive use except in southern climates, where the upper portion of the pole decays nearly as rapidly as the butt, and where the tropical insects, marine worms, and water have destructive effects on unprotected wood.

The tops of the poles are usually cut wedged shape or trimmed to a conical shape. Many companies do not treat their pole tops, although it is desirable to retard decay by applying a liberal coating of linseed oil and white lead, or some kind of a mineral paint. It is also preferable to paint the gains and the adjacent portion of the cross arms, for where one piece of wood is held in contact with another moisture collects and fungi of decay flourish.

The common practice is to use poles from 30 to 45 feet in length and placed in the ground to a depth of from 5 to 6½ feet. This length is of course increased to meet requirements of crossings, trees, etc., and under no circumstances should poles carrying a voltage of 220 volts or more be less than 20 feet above the ground. Frequently extra long poles are originally used and these sawed off and reset as they decay at the ground line.

Pole Spacing

The pole spacing is dependent upon the number and size of conductors carried, together with the nature of construction (whether straight line or having angles). The following table represents substantial practice for straight line work; for curves or angles, however, this spacing must be shortened.

Number of Conductors	Size of Conductors	Top Diameter of Pole	Spacing of Pole
3 to 6	Nos. 6 to 1	7 inches	150 feet
3	Nos. 0 to 4/0	8 inches	125 feet
6	Nos. 0 to 4/0	8 inches	110 feet
3	250,000 C. M.	9 inches	100 feet
6	250,000 C. M.	10 inches	80 feet

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Cross Arms

The kind of wood most largely used for cross arms are: Yellow Pine, Oregon or Washington Fir, Cedar, Cypress and White Pine. The standard arm is 3¼ inches by 4¼ inches; however, the longer length of arm required in high tension lines makes special arms necessary. These are made to order in sizes lrom 4x4 inches to 5x7 inches.

The length of the arm is determined by the number of conductors and the voltage carried. The spacing of conductors is taken up below, and reference is made to this table.

The cross arms are fastened to poles by a single through bolt fitted ith square ashers, and each side of the arm is braced from the bottom by means of galvanized steel braces. These braces are usually set at an angle with the pole from 45 to 60 degrees, and are fastened at the bottom by a single ⅝x3½-inch lag screw.

Double arms are necessary on terminal poles where the conductors are dead ended, on spaces over 150 feet, at angles of more than 20 degrees in the line, and where the cables are very heavy.

Double arms are held intact either by means of blocks inserted and held with through bolts or by means of long threaded bolts fitted with double nuts and square washers.

Pole Guying

Pole guying is commonly left to the judgment of a good construction foreman, and each company usually has their own standard methods. In general, however, the following rules should be followed:

1. The cable should be at least No. 3 galvanized steel stranded wire for light strain and from 5/16-inch to ½-inch cable for medium and heavy strains.
2. All guys should be placed before stringing the conductors.
3. Every pole which forms an angle of 10 degrees or more from the fixed direction of the line should have its spacing with the adjoining poles shortened by one-third or more, depending upon the angle, and should be properly guyed to counteract the pull of the conductors.
4. The guy cable should be given one complete turn around the poles and securely clamped with a 3-bolt galvanized iron clamp. At the anchor end the cable should be protected by a thimble where it passes through the eyelet.
5. There are several types of patent guy anchors on the market which can be easily installed, but care should be exercised in choosing the type of anchor suitable for the character of the soil. For regular country construction, the old log and guy rod combination seems more popular than any other type of anchor. They are, however, a little more costly to install.
6. Strain insulators of the spherical type should be inserted in all guy wire about 6 or 10 feet from the pole.
7. Pole bracing should take the place of guy wires where it is inconvenient to run the cable.

Insulators

Fogs, rain, dust and severe electrical storms all have an influence on the choice of insulators. In general, however, since insulator manufacturers have no real rating standard, and because of the fact that an insulator is always chosen with a safety factor to cover extreme conditions of climate and surges, the matter of choice has no distinct dividing line.

Porcelain and glass insulators may be obtained up to 20,000 volts, but the present demand seems to favor porcelain for voltages of 20,000 or more, and the base of the pin should fit the cross arm snugly.

Below 20,000 volts wooden pins or pine made up of a wooden bushing and steel pin may be used.

Conductor Spacing

The spacing should be such that the wires cannot swing within arcing distance of each other in the span, and will, therefore, depend upon the length of span. The following table represents good practice:

Line Voltage.	Interaxial Spacing.
2,200	18-inch
500	24-inch
1,500	40-inch
30,000	48-inch

THE DIESEL ENGINE

The term "oil engine," as generally used at the present time, is applied to internal-combustion engines that burn directly in the cylinder heavy liquid fuels of high boiling points, the fuel being injected into the compressed air shortly before or at the completion of the compression stroke. The distinguishing features of oil engines are that the fuel vapor is not absorbed by air before it is admitted to the cylinder, and that no inflammable mixture of vapor and air is compressed preceding its ignition. Oil engines compress air alone, and the heat of compression is used to ignite the fuel, which burns by consuming the oxygen of the air in the cylinder, the engine transforming the heat energy into work.

To facilitate and accelerate the burning of a liquid fuel it must either be vaporized, atomized, or intimately mixed with air immediately preceding its ignition. In Diesel engines the fuel is finely subdivided by air, and in this act of atomization is injected directly into the engine cylinder, where it is ignited automatically by the highly heated air in the cylinder. The combustion is not explosion-like, but is prolonged at constant pressure for the entire period during which the fuel is injected into the cylinder.

Properties of Diesel Engine Fuel

A desirable fuel for Diesel engines should have the following properties:

1. It should burn completely without leaving any residual matter in the cylinder, either in the form of soot, coke or ash.
2. It should be free from mechanical impurities which might clog the fuel pipes, the valves of the fuel pump, and the fine fuel passages in the fuel-injection valves and nozzles, or might cause excessive cylinder wear.
3. It should be sufficiently fluid at ordinary temperatures to flow readily to the fuel pump and thence to the fuel-injection valve.
4. It should be free from water, as water lowers the heating value of the oil and may prevent its ignition.
5. It should be free from highly volatile oils which will evaporate at ordinary temperatures and from an inflammable mixture with air, thus introducing a fire hazard.

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6. It should have a high heating value.

Complete burning of an oil so that no combustible or carbonaceous residues remain in the cylinder, the exhaust being colorless, depends almost entirely on the type and the size of the engine, the fuel-valve and the atomizer construction, and the correct setting of the valves.

Fuels of Diesel Engines

Liquid fuels may be divided into three groups, in which the fuels are radically different in structure, chemical constitution, and properties, and accordingly behave differently in the Diesel engine. The first group comprises fuels made up of mixtures of saturated and unsaturated hydrocarbons, relatively high in hydrogen, as petroleums and lignite-tar oils. The second group of fuels is composed principally of aromatic hydrocarbons, or benzol derivatives. It comprises coal tar oils, coal tars and miscellaneous tars. The third group comprises vegetable oils, which are glycerides of fatty acids.

Fuels of the first group are particularly valuable for use in Diesel engines, as they lend themselves to the formation of oil gas at temperature of 400° to 500° C. The gas is more readily formed and its ignition takes place more readily if it has a high carbon content, that is, a proportionately large content of saturated hydrocarbons.

The liquid fuels of the second group mentioned, composed chiefly of aromatic hydrocarbons, are low in hydrogen, are ignited with difficulty, and do not burn readily in Diesel engines. The resistance to ignition and burning increases with coal-tar oils and is greatest with coal tars, which, with certain exceptions, are not suitable for Diesel engine fuels.

Specifications for Petroleum Oils Suitable for Diesel Engines

1. The specific gravity (density) must be 0.86 to 0.895 at 15° C.

2. The flash point must not be lower than 60° C.

3. Tests to determine the boiling-point range must be made with a 100 c. c. sample. At least 90 c. c. of the oil should be distilled at 350° C., and if distillation is continued, until the residue is coked, the coke should not weigh in excess of 0.5 gram.

4. Acidity. The heavy gas oil must be free of mineral acids. For testing, the use of methyl orange as applied to kerosene should be used.

5. Water and mechanical impurities. The oil should be entirely clear and should not contain any suspended matter visible to the naked eye after filtering.

6. Ash content. On evaporating 50 grams of the oil to dryness in a platinum dish, no weighable quantities of ash must remain.

7. The viscosity must not exceed 2.50° Engler, measured with the Engler viscosimeter.

8. Heating value, determined by the bomb calorimeter, should be at least 10,000 calories per kilogram (18,000 B. T. U. per pound).

These specifications are practically ideal, especially in the matter of viscosity, which often varies from this figure. Since the fuel consumption of Diesel engines is so small, the increase of price scarcely is reflected in the cost of the power.

Specifications for Tar Oil Suitable for Diesel Engines

1. The tar oil must contain not more than 0.2% of solid matter insoluble in xylol; the noncombustible constituents must not exceed 0.05%.

2. The water content must not exceed 1%.

3. The residual coke must not exceed 3%.

4. At least 60% by volume of the oil must be distilled at 300° C.

5. The mean lower heating value must be not less than 8,800 calories per kilogram.

6. The flash point must not be below 65° C.

7. The oil must be thoroughly fluid at 150° C. If the oil is cooled at 80° C. and allowed to stand for half an hour, no solids must separate out.

Engine Factors Affecting Combustion

Manufacturers of Diesel engines are constantly striving to improve and construct the engines with a view to burning a greater variety of fuels, and in particular to make possible the burning of the heavier fuel oils and residues that are produced in great abundance in oil refining.

The following factors influence the thoroughness of the combustion: Size and speed of engine; atomizer construction and atomization of the fuel; degree to which the fuel spray is mixed with the air of combustion; and the shape of the combustion space.

In small engines the provision of water-cooled surfaces for the cylinder and cylinder head relatively large in proportion to the size of the combustion space is more effective than a similar provision in larger engines. Effective cooling is especially noticeable at low engine loads. The engine speed affects the speed of the fuel injection. In high-speed engines the fuel is injected during a period of one one-hundredth of a second, whereas in large low-speed engines the injections may last over a period of one-twentieth of a second. There are definite limits to the velocity with which a fuel can be burned; aside from being influenced by the character of the fuel, the velocity is chiefly controlled by the speed of the chemical reaction. As part of the fuel burns with the formation of carbon dioxide and water vapor, and possibly carbon monoxide, these gases reduce the activity of the oxygen toward the remainder of the fuel. With more time available for burning a fuel, and with equally thorough atomization, the combustion will be more thorough, or, what is more important, the higher may be the boiling point of the oil.

Heavy oils and residues demand higher injection-air pressure, so that the fuel will be broken into extremely small particles. The boiling-point temperatures of oils advance with an increase in pressure; further, the higher the boiling points of the oils the smaller is their vapor volume and the greater the volume of air required for their combustion.

A small combustion space, with highly-compressed air, greatly aids the thorough mixing of oil vapor and air. These considerations also explain why the combustion space of the cylinder should not be split up and have pockets, but have smooth walls, so that the fuel particles can travel through the air more rapidly. For the same reason the piston floor should be so shaped and the atomizer nozzle so constructed that the fuel spray will be spread over the entire cylinder area and, in being propelled forward by the force of the injection, oil will be diffused through the air of combustion.

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Lubricating Oils for Diesel Engines

Two kinds of oils are used for lubricating Diesel engines—engine oil and cylinder oil.

Engine oil is used for the lubrication of the main, the crank-pin, and the piston-pin bearings, and of the cam-shaft bearings, and for the oil baths into which the cams and the cam-shaft dip. A pure mineral oil used for general engine-bearing lubrication will fill these requirements.

Cylinder oil is used for the lubrication of the working cylinders and the air-compressor cylinders. It should be stable at the relatively high temperatures of the piston and the cylinders of a Diesel engine, and should maintain the desired lubricating properties at these temperatures; it should not vaporize readily, nor should it decompose at a temperaure lower than 300° C. High grade oils like those used in automobile engine lubrication are used.

Comparative Advantages and Disadvantages of Diesel Engines and of Steam Turbines for Generating Power

Advantages of Steam-Turbine Plants

1. Unlimited size of generating units.
2. High rotative speed, reducing size of generating units, and cheapening turbine and alternator construction.
3. Low installation cost.
4. High overloading capacity.
5. Ability to use under the boiler all classes of fuels (solid, liquid, or gaseous), including the cheaper varieties of inferior-grade coals.

Disadvantages of Steam-Turbine Plants

1. The fuel economy is greatly dependent on the skill of the operating force and the degree of thoroughness with which the installation is maintained at operating efficiency.
2. Dangers and drawbacks of boiler operation.
3. Boiler losses generally, and fuel losses in firing up and in banking boilers and in ash and clinkers.
4. Exacting requirements relating to circulating water for condensing the steam, one of the deciding factors in the commercial success of a steam plant.

Advantages of Diesel-Engine Plants

1. Very high thermal efficiency and lower absolute heat rate, independent of the size of unit.
2. Absence of all boilers, smoke and soot.
3. Constant readiness for operation.
4. No fuel losses in firing up and in unconsumed coal in ash as in steam plants.
5. Small volume of cooling water required.
6. Use of cheap liquid fuels, such as petroleum residues, coal-tar oils, and certain coal tars.

Disadvantages of Diesel-Engine Plants

1. Limited size of units (at present 4,000 horse power).
2. Massive foundations necessary.
3. High consumption of lubricating oil.
4. High installation cost.

COMPARATIVE ECONOMIES OF DIESEL AND EXPLOSION OIL ENGINES

ITEM	Diesel Engine, European					Diesel Engine, American					Explosion Oil Engine, European					Explosion Oil Engine, American				
	Load	Fuel per H. P. Hour—Lbs.	Per Cent.	Barrels per Year	Fuel Cost per H. P. Year (8,760 H. P. Hours)	Load	Fuel per H. P. Hour—Lbs.	Per Cent.	Barrels per Year	Fuel Cost per H. P. Year (8,760 H. P. Hours)	Load	Fuel per H. P. Hour—Lbs.	Per Cent.	Barrels per Year	Fuel Cost per H. P. Year (8,760 H. P. Hours)	Load	Fuel per H. P. Hour—Lbs.	Per Cent.	Barrels per Year	Fuel Cost per H. P. Year (8,760 H. P. Hours)
Fuel consumption or cost at different loads	4/4	0.42	100.0	863	$11.50	4/4	0.48	100.0	986	$13.15	4/4	0.60	100.0	1232	$16.43	4/4	0.75	100.0	1540	$20.53
	3/4	0.44	104.8	678	12.05	3/4	0.50	104.2	770	13.68	3/4	0.65	108.3	1013	18.11	3/4	0.83	110.7	1280	23.76
	2/4	0.50	119.0	685	13.70	2/4	0.58	120.8	610	16.27	2/4	0.75	125.0	770	20.53	2/4	0.95	126.7	975	26.00
Oil consumed for lubrication, gallons per year	360–550					360–550					1,100–1,460					1,100–1,460				
Cost of lubrication	$128 to $193 per year, or $1.70 to $2.60 per horse power year					$128 to $193 per year, or $1.70 to $2.60 per horse power year					$380 to $510 per year, or $5.10 to $6.80 per horse power year					$380 to $510 per year, or $5.10 to $6.80 per horse power year				
Cost of installation, including building	$90 per horse power					$90 per horse power					$60 per horse power					$60 per horse power				

Cost of fuel oil taken as at $1.00 a barrel of 320 pounds; cost of lubricating oil taken as at 35c a gallon.

Compiled from Bull. 156, U. S. Bureau of Mines.

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COMPARISON OF DIESEL AND SEMI-DIESEL TYPE OIL ENGINES

The chief difference between the Diesel and the Semi-Diesel oil engines lies in the method of injecting the fuel oil into the cylinders, and the pressure in the cylinders at the end of the compression stroke.

In the Diesel engine, a plunger pump under the control of the governor, delivers oil into passages leading into the cylinder. This passage is also connected to a receiver in which an air pressure of about 1,000 pounds is maintained.

A cam on the main shaft of a two cycle, and on the auxiliary shaft of a four cycle engine, opens a needle valve about three degrees before the piston has reached the end of the compression stroke and allows the high pressure air to blow into the cylinder, carrying with it the oil in the form of a spray. This needle valve remains open about 10% of the power stroke of the piston. The pressure in the cylinder at the time the needle valve opens and oil injection begins is about 500 pounds.

The high temperature of the air in the combustion space, due to this compression, is sufficient to ignite the oil when it is blown into a cold cylinder. The heating of any tubes or plugs for starting is, because of this, unnecessary. The oil, which is in the form of a very fine spray, begins to burn immediately on entering the cylinder, and continues to burn as long as it is blown in, which is as long as the needle valve is open or about 10% of the stroke of the piston.

The admission of the oil into the cylinder is never supposed to be rapid enough to increase the pressure above that of compression. In the original Diesel engines, Mr. Diesel specified an engine in which the temperature of combustion never exceeded the temperature of compression.

The pressure distribution in the Diesel engine differs from that in the Semi-Diesel in that in the Diesel the pressure never rises above that of compression, but on account of the burning of the fuel as the piston advances from the head end on the power stroke, the tendency is to maintain this pressure up to the point where the admission of the oil is cut off; while in the Semi-Diesel the burning of the fuel is so rapid that the pressure is somewhat increased above that of compression while the piston is still on the head end center, and combustion is nearly complete by the time the piston starts to advance.

The high pressure air required for blowing the oil into the cylinder is compressed by a two or three stage air compressor which is usually a built-in part of the engine, the air being stored in small air receivers or bottles.

The large oil engines are nearly always of the Diesel type. They are mostly four cycle, but some builders are now furnishing them of the two cycle type for marine purposes on account of their being of less weight and more easily reversed.

In the Semi-Diesel engine the oil is not blown into the cylinder with air under high pressure, but is forced in through a nozzle by a plunger pump which is controlled by the governor. The operation of the pump is so timed that the admission of oil to the cylinder begins several degrees before the crank reaches the head end center and ceases when it is not more than five degrees past the center.

The oil enters the cylinder through a very small hole in the nozzle. The nozzle is sometimes constructed in such a way as to cause the oil to be sprayed on entering the cylinder, but frequently the spraying is all caused by the high velocity of the oil when it strikes the walls of the combustion space. The compression in Semi-Diesel engines varies, some builders using as low as 150 pounds, but the tendency at present is to increase the compression in this type of engine as high as 250 pounds.

In those using the lower compression, the heat of compression alone is not sufficient to ignite the fuel when it is injected into the cylinder. In these engines metal in some form, such as hot balls, hot plates, or combustion chambers, which are not cooled by the water jacket and which are kept hot by the heat of combustion, must be used.

To prevent these hot balls, plates, etc., from becoming overheated, when the engine is heavily loaded, and causing so-called fuel pounding, a little water is admitted to the combustion chamber. Such engines are often called water injection or wet engines.

In engines using the higher compression, the heat of compression alone is sufficient to ignite the oil after the engine is warmed up, and in such no hot balls or plates or water injection need be used.

In either of these engines, however, some form of tube or bulb, either connected to or placed in the combustion chamber, and heated by a torch, or electric current, must be used in starting, as the heat of compression alone is not sufficient to start a cold engine.

The smaller oil engine units are mostly of the Semi-Diesel type. They are built both two and four cycle, but the greater number, particularly in the small units, are two cycle.

—Courtesy of O. C. Estergreen, Chicago Pneumatic Tool Co.

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U. S. Standard Schedule of Flanged Fittings and Flanges

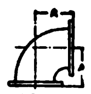
STANDARD WEIGHT 125 LBS. WORKING PRESSURE

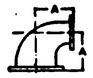
Size	A	B	C	D	E	F	G	Short Body Red Tees & Crosses: *Size of Outlets	Short Body Red Tees & Crosses: J	Short Body Red Tees & Crosses: K	Short Body Red Laterals: *Size of Branches	Short Body Red Laterals: L	Short Body Red Laterals: M	Short Body Red Laterals: N	Short Body Red Laterals: O	Flanges: Diameter	Flanges: Thickness	Bolts: Diameter of Bolt Circle	Bolts: Number of Bolts	Bolts: Diameter of Bolts	Minimum Metal Thickness
1	3½	5	1¾	7½	5¾	1¾										4	7/16	3	4	7/16	7/16
1¼	3¾	5½	2	8	6¼	1¾										4½	½	3⅜	4	7/16	7/16
1½	4	6	2¼	9	7	2										5	9/16	3⅞	4	½	7/16
2	4½	6½	2½	10½	8	2½										6	⅝	4¾	4	⅝	7/16
2½	5	7	3	12	9½	2½										7	11/16	5½	4	⅝	7/16
3	5½	7¾	3	13	10	3	6									7½	¾	6	4	⅝	7/16
3½	6	8½	3½	14½	11½	3	6½									8½	13/16	7	4	⅝	7/16
4	6½	9	4	15	12	3	7									9	15/16	7½	8	⅝	½
4½	7	9½	4	15½	12½	3	7½									9¼	15/16	7¾	8	¾	½
5	7½	10¼	4½	17	13½	3½	8									10	15/16	8½	8	¾	½
6	8	11½	5	18	14½	3½	9									11	1	9½	8	¾	9/16
7	8½	12¾	5½	20½	16½	4	10									12½	1 1/16	10¾	8	¾	⅝
8	9	14	5½	22	17½	4½	11									13½	1⅛	11¾	8	¾	⅝
9	10	15¼	6	24	19½	4½	11½									15	1⅛	13¼	12	¾	11/16
10	11	16½	6½	25½	20½	5	12									16	1 3/16	14¼	12	⅞	¾
12	12	19	7½	30	24½	5½	14									19	1¼	17	12	⅞	13/16
14	14	21½	7½	33	27	6	16									21	1⅜	18¾	12	1	⅞
15	14½	22¾	8	34½	28½	6	17									22¼	1⅜	20	16	1	⅞
16	15	24	8	36½	30	6½	18									23½	1 7/16	21¼	16	1	1
18	16½	26½	8½	39	32	7	19	12"	13	15½	9"	26	25	1	27½	25	1 9/16	22¾	16	1⅛	1 1/16
20	18	29	9½	43	35	8	20	14"	14	17	10"	28	27	1	29½	27½	1 11/16	25	20	1⅛	1⅛
22	20	31½	10	46	37½	8½	22	15"	14	18	10"	29	28½	½	31½	29½	1 13/16	27¼	20	1¼	1 3/16
24	22	34	11	49½	40½	9	24	16"	15	19	12"	32	31½	½	34½	32	1⅞	29½	20	1¼	1¼
26	23	36½	13	53	44	9	26	18"	16	20	12"	35	35	0	38	34¼	2	31¾	24	1¼	1 5/16
28	24	39	14	56	46½	9½	28	18"	16	21	14"	37	37	0	40	36½	2 1/16	34	28	1¼	1⅜
30	25	41½	15	59	49	10	30	20"	18	23	15"	39	39	0	42	38¾	2⅛	36	28	1⅜	1 7/16
32	26	44	16				32	20"	18	24						41¾	2¼	38½	28	1½	1½
34	27	46½	17				34	22"	19	25						43¾	2 5/16	40½	32	1½	1 9/16
36	28	49	18				36	24"	20	26						46	2⅜	42¾	32	1½	1⅝
38	29	51½	19				38	24"	20	28						48¾	2⅜	45¼	32	1⅝	1 11/16
40	30	54	20				40	26"	22	29						50¾	2½	47¼	36	1⅝	1¾
42	31	56½	21				42	28"	23	30						53	2⅝	49½	36	1⅝	1 13/16
44	32	59	22				44	28"	23	31						55¼	2⅝	51¾	40	1⅝	1⅞
46	33	61½	23				46	30"	24	33						57¼	2 11/16	53¾	40	1⅝	1 15/16
48	34	64	24				48	32"	26	34						59½	2¾	56	44	1⅝	2
50	35	66½	25				50	32"	26	35						61¾	2¾	58¼	44	1¾	2 1/16
52	37	69	26				52	34"	27	36						64	2⅞	60½	44	1¾	2⅛
54	39	71½	27				54	36"	29	37						66¼	3	62¾	44	1¾	2 3/16
56	41	74	28				56	36"	29	39						68¾	3	65	48	1¾	2¼
58	42	76½	29				58	38"	31	40						71	3⅛	67¼	48	1¾	2 5/16
60	44	79	30				60	40"	33	41						73	3⅛	69¼	52	1¾	2 7/16
62	45	81½	31				62	40"	33	42						75¾	3¼	71¾	52	1⅞	2½
64	47	84	32				64	42"	34	44						78	3¼	74	52	1⅞	2 9/16
66	48	86½	33				66	44"	35	45						80	3⅜	76	52	1⅞	2⅝
68	50	89	34				68	44"	35	46						82¼	3⅜	78¼	56	1⅞	2 11/16
70	51	91½	35				70	46"	37	47						84½	3½	80½	56	1⅞	2¾
72	53	94	36				72	48"	40	48						86½	3½	82½	60	1⅞	2 13/16

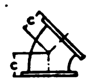
EXTRA HEAVY 250 LBS. WORKING PRESSURE

Size	A	B	C	D	E	F	G	Short Body Red Tees & Crosses: *Size of Outlets	Short Body Red Tees & Crosses: J	Short Body Red Tees & Crosses: K	Short Body Red Laterals: *Size of Branches	Short Body Red Laterals: L	Short Body Red Laterals: M	Short Body Red Laterals: N	Short Body Red Laterals: O	Flanges: Diameter	Flanges: Thickness	Bolts: Diameter of Bolt Circle	Bolts: Number of Bolts	Bolts: Diameter of Bolts	Minimum Metal Thickness
1	4	5	2	8½	6½	2										4½	11/16	3¼	4	½	½
1¼	4¼	5½	2½	9½	7¼	2¼										5	¾	3¾	4	½	½
1½	4½	6	2¾	11	8½	2½										6	13/16	4½	4	⅝	½
2	5	6½	3	11½	9	2½										6½	⅞	5	4	⅝	½
2½	5½	7	3½	13	10½	2½										7½	1	5⅞	4	¾	9/16
3	6	7¾	3½	14	11	3	6									8¼	1⅛	6⅝	8	¾	9/16
3½	6½	8½	4	15½	12½	3	6½									9	1 3/16	7¼	8	¾	9/16
4	7	9	4½	16½	13½	3	7									10	1¼	7⅞	8	¾	⅝
4½	7½	9½	4½	18	14½	3½	7½									10½	1 5/16	8½	8	¾	⅝
5	8	10¼	5	18½	15	3½	8									11	1⅜	9¼	8	¾	11/16
6	8½	11½	5½	21½	17½	4	9									12½	1 7/16	10⅝	12	¾	¾
7	9	12¾	6	23½	19	4½	10									14	1½	11⅞	12	⅞	13/16
8	10	14	6	25½	20½	5	11									15	1⅝	13	12	⅞	13/16
9	10½	15¼	6½	27½	22½	5	11½									16¼	1¾	14	12	1	⅞
10	11½	16½	7	29½	24	5½	12									17½	1⅞	15¼	16	1	15/16
12	13	19	8	33½	27½	6	14									20½	2	17¾	16	1⅛	1
14	15	21½	8½	37½	31	6½	16									23	2⅛	20¼	20	1⅛	1⅛
15	15½	22¾	9	39½	33	6½	17									24½	2 3/16	21½	20	1¼	1 3/16
16	16½	24	9½	42	34½	7½	18									25½	2¼	22½	20	1¼	1¼
18	18	26½	10	45½	37½	8	19	12"	14	17	9"	34	31	3	32½	28	2⅜	24¾	24	1¼	1⅜
20	19½	29	10½	49	40½	8½	20	14"	15½	18½	10"	37	34	3	36	30½	2½	27	24	1⅜	1½
22	20½	31½	11	53	43½	9½	22	15"	16½	20	10"	40	37	3	39	33	2⅝	29¼	24	1½	1 9/16
24	22½	34	12	57½	47½	10	24	16"	17	21½	12"	44	41	3	43	36	2¾	32	24	1⅝	1⅝
26	24	36½	13				26	18"	19	23						38¼	2 13/16	34½	28	1⅝	1 13/16
28	26	39	14				28	18"	19	24						40¾	2 15/16	37	28	1⅝	1⅞
30	27½	41½	15				30	20"	20½	25½						43	3	39¼	28	1¾	2
32	29	44	16				32	20"	20½	26½						45¼	3⅛	41½	28	1⅞	2⅛
34	30½	46½	17				34	22"	22	28						47½	3¼	43½	28	1⅞	2¼
36	32½	49	18				36	24"	23½	29½						50	3⅜	46	32	1⅞	2⅜
38	34	51½	19				38	24"	23½	30½						52¼	3 7/16	48	32	1⅞	2 7/16
40	35½	54	20				40	26"	25	31½						54½	3 9/16	50¼	36	1⅞	2 9/16
42	37	56½	21				42	28"	26½	33½						57	3 11/16	52¾	36	1⅞	2 11/16
44	39	59	22				44	28"	26½	34½						59¼	3¾	55	36	2	2 13/16
46	40½	61½	23				46	30"	27½	35½						61½	3⅞	57¼	40	2	2⅞
48	42	64	24				48	32"	29	37½						65	4	60¾	40	2	3

*Dimensions given or smaller.


ELBOW


REDUCING ELBOW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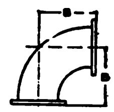
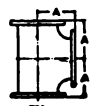

LONG TURN ELBOW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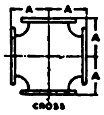
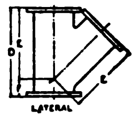

CROSS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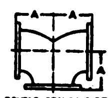
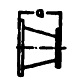
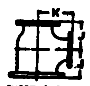
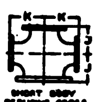
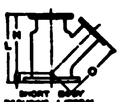

DOUBLE BRANCH ELBOW


REDUCER


SHORT BODY REDUCING TEE


SHORT BODY REDUCING CROSS


SHORT BODY REDUCING LATERAL

EXPLANATORY NOTES

1. Standard and Extra Heavy Reducing Elbows carry same dimensions center to face as regular Elbows of largest straight size.

2. Standard and Extra Heavy Tees, Crosses and Laterals, reducing on run only, carry same dimensions face to face as largest straight size.

3. If Flanged Fittings for lower working pressure than 125 lbs. are made, they shall conform in all dimensions except thickness of shell, to this standard and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.

4 Where long turn fittings are specified, it has reference only to Elbows which are made in two center to face dimensions and to be known as Elbows and Long Turn Elbows, the latter being used only when so specified.

5. All standard weight fittings must be guaranteed for 125 lbs. working pressure and extra heavy fittings for 250 lbs. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

6. All extra heavy fittings and flanges to have a raised surface 1/16" high inside of bolt holes for gaskets Thickness of flanges and center to face dimensions of fittings include this raised surface. Standard weight fittings and flanges to be plain faced. Bolt holes to be ⅛" larger in diameter than bolts. Bolt holes to straddle center lines.

7. Size of all fittings scheduled indicates inside diameter of ports.

8. Square head bolts with hexagonal nuts are recommended.

9. Double Branch Elbows, Side Outlet Elbows and Side Outlet Tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees and elbows.

10. Bull Head Tees or Tees increasing on outlet, will have same center to face and face to face dimensions as a straight fitting of the size of the outlet.

11. Tees, Crosses and Laterals 16 inches and smaller, reducing on the outlet, use the same dimensions as straight sizes of the larger port. Sizes 18 inches and larger, reducing on the outlet, are made in two lengths depending on the size of the outlet as given in the table of dimensions.

12. For fittings reducing on the run only a long body pattern will always be used. Y's are special and made to suit conditions. Double Branch Elbows are not made reducing on the run.

13. Steel Flanges, Fittings and Valves are recommended for Superheated Steam.

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Power Plant Data---Engines, Power Equivalents

AVERAGE STEAM PRESSURE THROUGHOUT THE STROKE AT ANY POINT OF CUT-OFF

Steam Pressure in pounds per sq. inch	Mean effective pressure in pounds per square inch for the whole stroke — Portion of stroke at which steam is cut-off					
	¾	⅝	½	⅜	¼	⅛
5	4.8	4.6	4.2	3.7	2.9	1.9
10	9.6	9.1	8.4	7.4	5.9	3.8
15	14.4	13.7	12.7	11.1	8.9	5.7
20	19.2	18.3	16.9	14.8	11.9	7.6
25	24.1	22.9	21.1	18.5	14.9	9.5
30	28.9	27.5	25.4	22.2	17.9	11.5
35	33.8	32.1	29.6	25.9	20.8	13.4
40	38.5	36.7	33.8	29.6	23.8	15.4
45	43.4	41.3	38.1	33.3	26.8	17.3
50	48.2	45.9	42.3	37.	29.8	19.2
60	57.8	55.1	50.7	44.5	35.7	23.1
70	67.4	64.3	59.2	52.4	41.7	26.9
80	77.1	73.5	67.7	59.3	47.7	30.8
90	86.7	82.6	76.1	66.7	53.6	34.6
100	96.3	91.8	84.6	74.1	59.6	38.4
110	106.	101.	93.1	81.5	65.6	42.5
120	115.2	110.2	101.5	89.4	71.5	46.1

STEAM USED EXPANSIVELY

The gain in fuel, derived by cutting off at various points, also the relation between the initial pressure of steam when cutting off and following full stroke, is as follows:

Pt. of Cutting Off	Per cent. of Gain in Fuel	Initial Pressure Required	
		Following Full Stroke	Cutting Off
⅞ stroke	12	1	1.01
¾ "	22	1	1.03
⅝ "	32	1	1.09
½ "	41	1	1.18
⅜ "	50	1	1.32
¼ "	58	1	1.67
⅛ "	68	1	2.6

When the pressure following full stroke or at cutting off is given the other can be found by the above ratio.

* * * *

The indicated horse power of an engine is the power developed by the steam on the piston without any deduction for friction.

The effective horse power of an engine is the actual and available horse power delivered to the belt or gearing, and is always less than the indicated.

HORSE POWER OF DOUBLE ACTING, SINGLE CYLINDER STEAM ENGINES

$$HP = \frac{P x L x A x N x F}{33000}$$

P = Gauge pressure at engine.
L = Length of stroke in feet.
A = Area of piston in square inches.
N = Number of strokes per minute.
F = Factor of cut-off. (See table Average Steam Pressure Throughout the Stroke at Any Point of Cut-off.) To determine F divide the steam pressure by the M. E. P. for given cut-off.

* * * *

An indicated horse power requires, in the best condensing engines, about 1¾ gallons of water evaporated per hour.

An indicated horse power, in large non-condensing engines, requires about 2½ gallons of water evaporated per hour.

An indicated horse power, in small non-condensing engines, requires from 3 to 10 gallons of water evaporated per hour.

MECHANICAL, ELECTRICAL AND HEAT EQUIVALENTS

1 H. P. =
- 746 watts.
- 0.746 K. W.
- 33,000 ft.-lbs. per minute.
- 550 ft.-lbs. per second.
- 2,545 heat-units per hour.
- 42.4 heat-units per minute.
- 0.707 heat-units per second.
- 0.175 lb. carbon oxidized per hour.
- 2.64 lbs. water evaporated per hour from and at 212° F.

1 H. P. Hour =
- 0.746 K.W. hours.
- 1,980,000 ft.-lbs.
- 2 545 heat-units.
- 273,740 k. g. m.
- 0.175 lb. carbon oxidized with perfect efficiency.
- 2.64 lbs. water evaporated from and at 212° F.
- 17.0 lbs. water raised from 62° F. to 212° F.

1 Kilowatt =
- 1,000 watts.
- 1.34 horse-power.
- 2,654,200 ft. lbs. per hour.
- 44,240 ft.-lbs. per minute.
- 737.3 ft.-lbs. per second.
- 3,412 heat-units per hour.
- 56.9 heat-units per minute.
- 0.948 heat-units per second.
- 0.2275 lb. carbon oxidized per hour.
- 3.53 lbs. water evaporated per hour from and at 212° F.

1 K. W. Hour =
- 1,000 watt hours.
- 1.34 horse-power hours.
- 2,654,200 ft-.lbs.
- 3,600,000 joules.
- 3,412 heat-units.
- 367,000 kilogram meters.
- 0.235 lb. carbon oxidized with perfect efficiency.
- 3.53 lbs. water evaporated from and at 212° F.
- 22.75 lbs. water raised from 62° to 212° F.

1 Watt =
- 1 joule per second.
- 0.00134 H. P.
- 3.412 heat-units per hour.
- 0.7373 ft.-lb. per second.
- 0.0035 lb. water evaporated per hour.
- 44.24 ft.-lbs. per minute.

1 Ft.-lb. =
- 1,356 joules.
- 0.1383 k. g. m.
- 0.000000377 K. W. hours.
- 0.001285 heat-units.
- 0.0000005 H. P. hour.

RANGES IN STEAM CONSUMPTION BY PRIME MOVERS
(For Estimating Purposes)

Simple Non-Condensing Engines	29- 45 lbs. per hour
Simple Non-Condensing Automatic Engines	26- 40 lbs. per hour
Simple Non-Condensing Corliss Engines	26- 35 lbs. per hour
Compound Non-Condensing Engines	19- 28 lbs. per hour
Compound Condensing Engines	12- 22 lbs. per hour
Simple Duplex Steam Pumps	120-200 lbs. per hour
Turbines, Non-Condensing	28- 60 lbs. per.K. W. hour
Turbines, Condensing	12- 42 lbs. per K. W. hour

Mr. George M. Brill found in experiments conducted under actual steam plant conditions that by using an 8-inch bare steam pipe 60 feet long with an average pressure of 110.5 pounds by gauge, and with air 75.5° F., that 736.546 B. T. U. per square foot of surface per hour were lost. These results accord so closely with the experiments conducted by Prof. R. C. Carpenter of Cornell University, and Prof. M. E. Cooley of the University of Michigan, that it seems fair to use them as a premise in calculating in practical work.

* * * *

FOR EVERY DAY USE IN ENGINE ROOM

To find diameter of cylinder for a given power:

Multiply horse power of engine by 33,000; divide product by the product of length of cylinder × steam pressure × piston speed in feet per min.

Rule for finding contents in cubic feet of a cylinder of any given diameter:

Multiply the square of diameter in inches by .7854 and this product by length of stroke in inches. Divide last product by 1728, and the result is contents of cylinder in cubic feet.

The diameter of the valve rod should be 1/10 to 1/12 of the cylinder diameter; or from 1/350 to 1/300 of unbalanced area of slide valve. This last is considering the valve as a piston. Steel rods, of course, will bear being made smaller.

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SIZES OF STEAM PIPES FOR ENGINES

A common rule is that steam pipes supplying stationary engines should be of such size that the mean velocity of steam in them does not exceed 6,000 feet per minute, in order that the loss due to friction may not be excessive. In proportioning exhaust pipes the velocity should not exceed 4,000 feet per minute for stationary engines nor 6,000 feet for marine engines.

Having assumed a velocity of flow in the pipe supplying steam to the engine, the size of pipe ququired is such that its area is given by the formula,

$$\text{Pipe Area} = \frac{\text{Cylinder Area} \times \text{Piston Speed}}{\text{Mean Velocity of Steam in Pipe}}$$

Or since the areas are proportional to the squares of their diameters,

$$\text{Pipe Diameter} = \sqrt{\frac{(\text{Cylinder Diameters})^2 \times \text{Piston Speed}}{\text{Mean Velocity of Steam in Pipe}}}$$

This assumes that steam is admitted during full stroke.

PROPERTIES OF STANDARD BOILER TUBES AND FLUES*
Weights and Dimensions Are Normal

Diameters		Thickness		Wgt. per Ft.	Length of Tube per Sq. Ft.		Sq. Ft. of Surface per Lineal Ft.	
External	Internal	Ins.	BWG		External Surface	Internal Surface	External Surface	Internal Surface
1¾	1.560	.095	13	1.679	2.182	2.448	.458	.408
2	1.810	.095	13	1.932	1.909	2.110	.523	.473
2¼	2.060	.095	13	2.186	1.697	1.854	.589	.539
2½	2.280	.109	12	2.783	1.527	1.673	.654	.597
2¾	2.532	.109	12	3.074	1.388	1.508	.719	.662
3	2.782	.109	12	3.365	1.273	1.373	.785	.728
3¼	3.010	.120	11	4.011	1.175	1.269	.850	.788
3½	3.260	.120	11	4.331	1.091	1.171	.916	.853
3¾	3.510	.120	11	4.652	1.018	1.088	.981	.918
4	3.732	.134	10	5.532	.954	1.023	1.047	.977
4½	4.232	.134	10	6.248	.848	.902	1.178	1.107
5	4.704	.148	9	7.669	.763	.812	1.308	1.231
6	5.670	.165	8	10.282	.636	.673	1.570	1.484
7	6.670	.165	8	12.044	.545	.572	1.832	1.746
8	7.670	.165	8	13.807	.477	.498	2.094	2.008
9	8.640	.180	7	16.955	.429	.442	2.356	2.261
10	9.594	.203	6	21.240	.381	.398	2.617	2.511
11	10.560	.220	5	25.329	.347	.361	2.879	2.764
12	11.542	.229	..	28.788	.318	.330	3.141	3.021
13	12.524	.238	4	32.439	.293	.304	3.403	3.278
14	13.504	.248	..	36.424	.272	.282	3.665	3.535
15	14.482	.259	3	40.775	.254	.263	3.926	3.791
16	15.460	.270	..	45.359	.238	.247	4.188	4.047

*From the National Tube Company's Book of Standards.

LOSS OF HEAT FROM STEAM PIPES

Loss of Heat from Bare Steam Pipes

A bare pipe carrying steam and made of steel, iron or other conducting material, loses heat by convection to the surrounding air and by radiation to the surrounding objects, both of which cause a loss of steam by condensation.

For bare steam pipes this loss may be taken as 2.7 B.T.U. per hour per square foot of surface per degree Fahrenheit difference between the temperatures of the steam and the outside air. Thus, if the pressure of the steam is 120 pounds absolute, the corresponding temperature being 341°, and the temperature of the air 60°, then the loss per hour per foot length from a 4-inch steam pipe, the external surface of which is 1.178 square feet per foot of length, will be $1.178 \times (341 - 60) \times 2.7 = 894$ B.T.U.

Condensation in Bare Steam Pipes

The corresponding condensation can be found by dividing this heat quantity by the latent heat of steam at the given pressure. In the example given above, the latent heat of steam at 120 pounds pressure, absolute, is 877.2 B.T.U. Therefore the condensation per hour per foot length of pipe is $894 \div 877.2 = 1.02$ pounds.

Steam Pipe Coverings

This loss is lessened in practice by covering the steam pipe with a material that will offer a greater resistance to the flow of heat than that offered by the material of the pipe. A good material for this purpose should not suffer serious deterioration from the heat or vibration to which it would be subjected in practice; and in all cases where damage from fire might result, it should never consist of combustible matter. Any covering should be kept perfectly dry, as still water is an excellent carrier of heat.

The best insulating substance known is air confined in minute cells, and the best nonconducting coverings owe their efficiency to the numerous air cells in their structure. In general the value of a covering is inversely proportional to its weight, and other things being equal, the incombustible mineral substances are to be preferred to combustible material. No coverings should be less than one inch in thickness.

Hair or wool felt and most of the better nonconducting materials have the disadvantage of becoming charred at high temperature and partly losing their insulating power. There is also the danger of taking fire. Mineral wool, a fibrous material made from blast furnace slag, is the best noncombustible covering, but being brittle it is liable to fall to a powder when subjected to jarring.

Pipe covering may be sectional, or plastic. The former is built up in sections and attached to the pipe by bands, which allow easy removal of the covering. The latter is put on in a soft, plastic condition, and is hardened in place; it obviates joints and adheres closely to the pipe.

The table shown on following page, taken from the various sources noted, gives the results of experiments on steam pipe coverings. In almost all cases the figures given are the averages of a number of tests.

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A brief description of some of these coverings is given below:

No. 4. A layer of asbestos paper 1/32-inch thick next to the pipe, then the hair felt, then a layer of paper, and outside of all a canvas covering.

No. 5. The hair felt was bound tightly around the pipe, with no canvas covering; it had a layer of asbestos paper under it.

No. 6. A covering composed of two layers wound in reverse direction with ropes of carbonized silk; the inner layer 2½ inches wide and ½-inch thick; the outer layer 2 inches wide and ¾-inch thick, over which was wound a network of wire; ⅛-inch asbestos next to pipe.

No. 7. A grade known as high-pressure remanit; encased in canvas.

No. 8. A grade known as intermediate-pressure remanit; encased in canvas.

Nos. 9 and 10. Solid sectional covering of granulated cork with ⅛-inch asbestos paper next to pipe.

No. 11. Eighty-five per cent carbonate of magnesia. Average of a number of tests of moulded sectionals, thickness of covering ranging from 2.20 to 2.71 inches.

No. 12. Carbonate of magnesia with some asbestos fiber; outside finished with canvas.

No. 14. Average of tests, thickness of covering ranging from 1.12 to 1.19 inches.

No. 15. Moulded setcional covering composed of about 90 per cent carbonate of magnesia.

No. 17. Similar, except in thickness, to No. 12.

Nos. 18, 19, 20 and 21. Laminated sectional, composed of a number of layers of asbestos paper in which were imbedded small pieces of sponge.

No. 23. A sectional covering composed of an inner layer of earthy material covered by a layer of wool felt.

No. 25. Laminated sectional with ⅛-inch asbestos paper next to pipe.

No. 26. Made of thin sheets of corrugated asbestos paper, stuck together with silicate of soda.

Nos. 27 and 28. Similar to No. 26.

Nos. 32 and 33. Mixed with water and plastered on the pipe.

SAFE WORKING PRESSURES

Numerous factory tests to determine the actual bursting pressure of wrought pipe have proved Barlow's formula to be correct. This formula follows:

$$BP = \frac{2T \times TS}{OD}$$

in which BP equals bursting pressure in pounds per square inch.
in which T equals thickness of the wall in inches.
in which OD equals outside diameter of the pipe in inches.
in which TS equals tensile strength of material per square inch.

The value of TS was determined from actual tests to be 40,000 pounds per square inch for butt welded steel pipe and 50,000 pounds for lap welded steel pipe.

STEAM PIPE COVERINGS

Number	Kind of Covering	Size of Pipe, Inches	Thickness of Covering, Inches	B.T.U. per Sq. Ft. per Hour per Degree Difference of Temperature	Per Cent. Heat Lost	Authority
1	Bare pipe	..	....	2.7	100.	
2	Mineral wool	8	1.30	0.285	10.6	Brill
3	Rock wool	8	1.60	0.256	9.5	Brill
4	Hair felt	2	0.96	0.387	14.3	Jacobus
5	Hair felt	8	0.82	0.422	15.6	Brill
6	Remanit	2	1.51	0.302	11.2	Stott
7	Remanit	2	1.30	0.363	13.4	Jacobus
8	Remanit	2	0.88	0.434	16.1	Jacobus
9	Solid cork	2	1.68	0.348	12.9	Stott
10	Solid cork	2	1.20	0.427	15.8	Stott
11	Magnesia	2	2.41	0.302	11.2	Stott
12	Magnesia	10	1.37	0.354	13.1	Barrus
13	Magnesia	8	1.25	0.384	14.2	Brill
14	Magnesia	2	1.16	0.439	16.3	Stott
15	Magnesia	4	1.12	0.465	17.2	Norton
16	Magnesia	2	1.08	0.304	11.3	Jacobus
17	Magnesia	2	1.08	0.531	19.7	Barrus
18	Asbestos sponge felted	2	1.14	0.260	9.6	Jacobus
19	Asbestos sponge felted	10	1.63	0.280	10.4	Barrus
20	Asbestos sponge felted	2	1.21	0.490	18.1	Barrus
21	Asbestos sponge felted	2	1.24	0.532	19.7	Stott
22	Manville sectional	8	1.70	0.350	13.0	Brill
23	Manville sectional	4	1.25	0.453	16.8	Norton
24	Manville sectional	2	1.31	0.572	21.2	Pauling
25	Asbestos air cell	2	1.26	0.486	18.0	Stott
26	Asbestos air cell	4	1.12	0.525	19.4	Norton
27	Asbestos air cell	2	0.96	0.716	26.5	Jacobus
28	Asbestos air cell	2	1.02	0.793	29.4	Barrus
29	Asbestos fire felt	8	1.30	0.502	18.6	Brill
30	Asbestos fire felt	2	1.00	0.721	26.7	Paulding
31	Asbestos fire felt	2	0.99	0.766	28.4	Jacobus
32	Fossil meal	8	0.75	0.879	32.6	Brill
33	Riley cement	8	0.75	0.953	35.3	Brill

RULE TO ASCERTAIN THE CAPACITY OF CISTERNS AND TANKS

Cylindrical Shape

First multiply the square of the diameter in feet by the depth of tank in feet.

For capacity in hogsheads, multiply the above product by 373 and divide by 4000.

For capacity in barrels, multiply by 373 and divide by 2000.

For capacity in gallons, multiply by 47 and divide by 8.

Tapering Shape

For tanks that are tapering measure the diameter four-tenths of the distance from the large end, and proceed as with cylindrical shape.

Square or Oblong Shape

First multiply the inside length by the width and by the depth (all in feet).

For capacity in hogsheads, multiply this product by 19 and divide by 160.

Cor capacity in barrels, multiply by 19 and divide by 80.

For capacity in gallons, multiply by 7.48.

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How Large a Compressor Shall I Buy?

In selecting an air compressor for a new mine, quarry or contract, the first consideration is naturally to determine what machines or tools and how many are to be operated by the air power.

Practically all handbooks on compressed air, and many manufacturers' catalogs, have for many years contained tables purporting to show the air consumption of a number of different drills of various sizes. It is obvious that a table cannot be prepared that will be correct for all conditions, as for instance: if eight drills were working in two headings of a tunnel it is probable that all of them would be working at the same time and would, therefore, require eight times the amount of air that a single drill would. If, on the other hand, eight drills were scattered around over an excavation to be used for putting in "pop" holes, it is extremely unlikely that over five or six would ever be working at the same time, so a compressor supplying five or six times enough air for one drill would be ample to take care of the entire eight.

A little reflection will show that the only factors that need to be seriously considered in estimating the requirements to take care of a number of drills, are the air consumption of each drill and the greatest number of drills that will be operated at one time. If the air receivers are of exceptionally large capacity, they may be counted on to assist materially in carrying the peak load, but under the majority of conditions, the receiver capacity may be disregarded, as receivers are usually only large enough to equalize the fluctuations in pressure due to the pulsation of the compressor, and serve merely as equalizers and not as storage reservoirs.

In comparatively large installations, by which is meant those of twenty or more drills, the compressor capacity may be estimated from the probable average reciprocating time of the drill. For instance, if fifty drills are to be installed and it is expected that each one will be actually running 75 per cent of the time, the air required will be 75 per cent of the amount of air one drill takes, multiplied by 50. This method of estimating should only be used for comparatively large installations. For instance, if two drills are to be installed, which will probably run 75 per cent of the time, it is, of course, necessary to furnish compressor capacity enough for the two instead of one and one-half; since both would be working at the same time. This method of estimating should never be used unless the probable lost time of the drills is equal to at least one drill. That is, 75 per cent of 2 equals 1½. 75 per cent of 3 equals 2¼. 75 per cent of 4 equals 3. Therefore we could expect only three drills out of four to be working on the last mentioned installation and could, therefore, plan on compressor capacity enough for three drills. We cannot, however, assume 2¼ out of 3, as it is evident that either two or three drills will be working and so it would be necessary to have enough air to run the entire three.

Other Air Uses

In addition to the actual requirements of the drills or other main installation of machinery, a liberal allowance should be made for use in other machines such as pumps, motors and forges; and also for leakage. It is folly to attempt to discourage the legitimate use of compressed air, for this is a very economical and efficient method of transmitting power and accomplishing certain results, but great emphasis should be placed on the unnecessary waste of it, especially by leakage.

Losses From Leakage

Very few people fully realize the losses due to leakage of compressed air. A hole 1/16-inch in diameter will cause a loss of about six cubic feet of free air per minute at 100 pounds pressure. A ⅛-inch hole will allow a loss of over 25 cubic feet per minute, or enough to run a small tool. A ¼-inch hole will allow over 100 cubic feet per minute to escape, or enough to run a modern rotating hand hammer drill or a stoper. It is seldom that the leakage from a ¼-inch hole would go unnoticed, but a multitude of smaller leaks are frequently allowed, which reduce the total efficiency of the installation to an almost unbelievable extent.

It is only necessary to run the compressor through the noon hour, or at some other time when no machines are working, to see just how many revolutions the compressor has to make to take care of leakage alone, since at that time no effective work is being done. If it requires 50 revolutions of the compressor per minute to keep up the pressure with no machines running, it is evident that if the compressor is normally running at 200 revolutions per minute, only 150 of the revolutions are furnishing air for efficient use, and the other 50 are merely taking care of the leakage. Unfortunately, this test is very likely to leave one with a rather unsatisfactory opinion of the plant; but it serves the useful purpose of impressing one with the necessity of making a liberal allowance for leakage in future installations, and still more important, makes it easy to keep leakage at the minimum, by checking up on this loss from time to time, as machines are added and pipe lines extended.

The same considerations, of course, apply to cutting shed, foundry or shop air power plants.

—By Lee A. Knights, Mine & Quarry.

COMPRESSOR DATA REQUIRED FOR FULL AND CORRECT REPLY

METHOD OF DRIVE

If Steam

1. Maximum and minimum pressure at compressor throttle, or
2. Boiler pressure, distance from boiler to compressor, and size of steam pipe?
3. To operate condensing or non-condensing?
4. Is company to furnish condenser?
5. Have you any preference as to type of engine or steam valve to be used? Advise in detail.
6. Special features or remarks?

If Electric

7. Voltage at motor?
8. Direct current or alternating?
9. If alternating, phases and cycles?
10. Gear, chain or belt drive?
11. Slow, moderate or high-speed motor?
12. Have you any preference as to type or make of motor?
13. Special features or remarks?

VOLUME OF AIR REQUIRED

14. Maximum air, cubic feet per minute? Free or compressed air? State which.
15. Maximum gauge pressure at machine, or
16. Maximum gauge pressure at work?
17. Distance from compressor to work?
18. Character of work to be done?
19. Altitude above sea level where compressor will be located?
20. Special features or remarks?

GENERAL CONDITIONS

21. Floor space and head room, if limited?
22. Is manufacturer to install?
23. Character of work for which required, such as gas compression, air lift pumping, handling oil or acids, etc.?
24. Approximate hours per day compressor will operate?
25. Comment and remarks?

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AIR RECEIVER CALCULATIONS

The first type of problem considered here is the determination of the amount of free air available in a receiver while the air pressure is dropping from one given pressure to another. For example: An air receiver has a capacity of 500 cu. ft. The pressure in the receiver is 100 lb. per sq. in. gage. How long is it possible to operate a drill from the receiver alone if the drill requires 100 cu. ft. of free air per minute and the lower limit of operating pressure is 70 lb. per sq. in. gage?

The formula connectng pressure, volume, temperature, and weight of air is

$$PV = wRT$$

where

P = pressure in lb. per sq. ft. absolute;
V = volume in cu. ft.;
w = weight of air in lb.;
R = constant = 53.4;
T = absolute temperature (Fahrenheit + 460).

At the start of the operation of the drill let the weight of the air in the receiver be w_1, V the volume of the receiver, and T the absolute temperature which remains constant. Pet P_1 be the pressure in lb. per sq. ft.

Then at the start,

$$P_1V = w_1RT \qquad (1)$$

Let w_2 be the weight of air in the receiver when the drill stops and the pressure has dropped to 70 lb. gage. Let P_2 be the pressure in lb. per sq. ft.

Then at the finish,

$$P_2V = w_2RT \qquad (2)$$

From (1) $w_1 = P_1V/RT$
From (2) $w_1 = P_2V/RT$

The weight drawn from the receiver is $w_1 - w_2$.

How many cubic feet of air at atmosphere pressure has been drawn out?

Let P_3 = the atmospheric pressure in lb. per sq. ft.

Let Vat = the volume at atmospheric pressure.

Then:

$$P_3\,Vat = (w_1 - w_2)RT = \frac{P_1V - P_2V}{RT} \times RT$$

or

$$Vat = V(P_1 - P_2)/P_3 \qquad (3)$$

The pressures are in lb. per sq. ft., but as the unit of conversion to sq. in., 144, appears in both the numerator and denominator of the right-hand member, it might be cancelled, leaving the symbols representing lb. per sq. in. In the numerator, as we have the difference of two pressures, either gage or absolute pressure may be used. P_3 is, then always the absolute pressure of the atmosphere in lb. per sq. in. We shall assume it to be 15. To solve the numerical problem: V = 500, P_1 = 100, P_2 = 70, P_3 = 15.

$$Vat = 500\ (100 - 70)/15 = 1{,}000$$

The receiver will supply 1,000 cu. ft. of free air above 70 lb. The drill will operate 1,000 ÷ 100 = 10 minutes.

The same formula is used to determine the time to raise the pressure in a receiver with a given compressor.

Example: A receiver has a capacity of 1,000 cu. ft. How long would it take a compressor supplying 500 cu. ft. of free air per minute to raise the pressure from 70 lb. per sq. in. gage to 100 lb. per sq. in. gage.

First, how many cubic feet of free air must be put in?

$$Vat = 1000\ (100 - 70)/15 = 2{,}000$$

Then 2,000/500 = 4 minutes.

Sometimes it may be necessary to help out a compressor when an intermittent drain of the air exceeds the capacity of the compressor, such as the operation of an air hoist for hoisting or hauling.

Example: A small geared hoist pulling cars out of a tunnel requires 120 cu. ft. of compressed air per minute at 60 lb. per sq. in. gage. Whatever the pressure in the receiver, the air is wire-drawn through the throttle valve to 60 lb. The haul requires six minutes. The compressor supplies 300 cu. ft. of free air per minute. The receiver may be pumped up to 90 lb. per sq. in. gage at the start and the pressure must not drop lower than 60 lb. at the finish of the haul. What must be the size of the receiver?

The free air used by the hoist each minute is $75/15 \times 120 = 600$ cu. ft.

The air receiver must supply 600 — 300 = 300 cu. ft. per minute, or a total of 1,800 cu. ft. of free air.

$$Vat - (P_1 - P_2)\ V/15$$
$$1{,}800 = 30\ V/15$$

V = 900 cu. ft., which is the needed capacity of the receiver.

The calculation of the size of a large underground storage reservoir for compressed air is a problem of this type.

Another style of problem requiring a different formula is this: There are two receivers containing air at some pressure. If a valve is opened connecting the two, what will be the pressure in both?

Let V_1 be the volume of A and let V_2 be the volume of B.

Before the valve is open let P_1 be the pressure in A in lb. per sq. ft., and w_1 the weight of air in A. Let P_2 and w_2 be the pressure and weight respectively in B.

After the valve is open, the total weight of air is $w_1 + w_2$ and the total volume is $V_1 + V_2$.

$$w_1 + w_2 = (P_1V_1 + P_2V_2)/RT$$

Let the resultant pressure be P.

$$\text{Then}\quad P(V_1 + V_2) = \left(\frac{P_1V_1 + P_2V_2}{RT}\right) + RT \qquad (4)$$

$$PV_1 + PV_2 = P_1V_1 + P_2V_2 \qquad (5)$$

Let us study this formula for a moment. As a symbol for pressure occurs in every term, we may divide through by 144, leaving the symbols representing lb. per sq. in. instead of lb. per sq. ft. The symbols represent absolute pressures. Let us denote the corresponding gage pressures by the subscript g, and rewrite the formula:

$(Pg + 15)V_1 + (Pg + 15)V_2 = P_1g + 15)V_1 + (P_2g + 15)V_2$.

The terms involving the atmospheric pressure cancel and leave gage pressures. So in this for-

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mula and in those derived from it the pressure may be gage or absolute and the pressures in lb. per sq. in. or per sq. ft.

To continue from (5)

$$P = \frac{P_1V_1 + P_2V_2}{V_1 + V_2}$$

Example: A has a capacity of 1,000 cu. ft. and the pressure is 90 lb. per sq. in. gage. B has a capacity of 500 cu. ft. and the pressure is 60 lb. per sq. in. gage. What will be the pressure if they are connected?

$$P = \frac{90 \times 1{,}000 + 60 \times 500}{1{,}500} = 80$$

The resultant pressure will be 80 lb. per sq. in. gage.

Another form of equation (5) is used in the calculation of compressed-air haulage systems to determine the size of the stationary storage so that when the tank on the locomotive is connected to it, this tank will be charged to a given pressure.

Let A be the stationary storage and B be the tank on the locomotive. P_1 is the pressure in the storage and is usually about 1,000 lb. per sq. in. gage. P_2 is the pressure in the locomotive tank when ready for charging and is usually about 250 lb. per sq. in. gage.

Example: The tank on the locomotive holds 48 cu. ft., and we wish to charge to 800 lb. per sq. in. gage. What should be the capacity of the stationary storage? Transposing equation (5)

$$PV_1 - P_1V_1 = P_2V_2 - PV_2$$

$$V_1 = \frac{V_2(P_2 - P)}{P - P_1} = \frac{V_2(P - P_2)}{P_1 - P}$$

$$V_1 = \frac{48\ (800 - 250)}{1{,}000 - 800} = 132 \text{ cu. ft.}$$

That is, if we have receiver capacity of 132 cu. ft. and pump it up to 1,000 lb. between chargings, we can charge instantly to 800 lb. To determine the capacity of the compressor, use equation (3) to determine the amount of free air to put in to bring the pressure back to 1,000. The air put in divided by the time in minutes between charging gives the free air per minute that must be supplied by the compressor.

—By Walter S. Weeks, Engineering and Mining Journal, June 11, 1921.

DISCHARGE OF AIR THROUGH AN ORIFICE

In Cubic Feet of Free Air Per Minute

Flowing From a Round Hole in Receiver Into the Atmosphere

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Receiver Gauge Pressure Pounds	Diameter of Orifice													
	1/32 inch	1/16 inch	1/8 inch	3/16 inch	1/4 inch	5/16 inch	3/8 inch	7/16 inch	1/2 inch	9/16 inch	1 inch	1 1/4 inch	1 1/2 inch	2 inch
	Discharge in Cubic Feet of Free Air per Minute													
2	038	.153	.647	2.435	9.74	21.95	39.	61	87.60	119.50	156	242.	350.	625.
5	.0597	.242	965	3.86	15.40	34.60	61 60	96 50	133.	189.	247	384.	550.	985
10	.0842	.342	.136	5.45	21.8	49.	87	136.	196	267	350	543.	780.	.....
15	103	.418	1.67	6.65	26.70	60.	107.	167	240	326	427	665.	960.	.....
20	119	.485	1.93	7.7	30.8	69	123	193	277	378	494	770.	.....	.....
25	.133	.54	2.16	8 6	34.5	77	138	216	310	422	550.	860.	.....	.....
30	.156	.632	2.52	10.	40	90	161	252	362.	493	645	1000.	.....	.....
35	.173	.71	2.80	11 2	44 7	100	179	280	400	550.	715	.....	.....	.....
40	.19	.77	3.07	12 27	49 09	110 45	196 35	306.80	441 79	601.32	785.40	.....	.....	.....
45	.208	.843	3.36	13.4	53.8	121	215	336	482	658.	860	.....	.....	.....
50	225	.914	3.64	14 50	58.2	130.	232	364	522	710.	930.	.....	.....	.....
60	.26	1.05	4.2	16.8	67	151	268	420	604.	622	.....	.....	.....	.....
70	295	1.19	4.76	19.	76.	171.	304.	476.	685.	930.	.....	.....	.....	.....
80	33	1 33	5.32	21.2	85.	191	340	532	765.	1004.	.....	.....	.....	.....
90	.364	1.47	5.87	23.50	94	211	376.	587	843.	.....	.....	.....	.....	.....
100	40	1 61	6.45	25.8	103.	231.	412	645	925	.....	.....	.....	.....	.....
125	.486	1.97	7.85	31.4	125.	282.	502	785	.....	.....	.....	.....	.....	.....

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Loss of Pressure in Compressed Air Transmission

The following tables give the drop in pressure per 1,000 feet of pipe, for different deliveries, and pipe sizes from 1 to 6 inch.

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Delivery in Cu. Ft. of Compressed Air per Min.	Equiv. Delivery in Cu. Ft. of Free Air per Min.	Size of Pipe, Inches: 1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	16
		Loss of Pressure, in Pounds, by Friction in 1000 Feet Lengths of Pipe																	
At 60 Pounds Gauge																			
9.84	50	18.24	5.06	1.95	.42	.13	.05												
14.73	75		11.34	4.33	.95	.29	.11	.05											
19.64	100		20.16	7.79	1.69	.52	.19	.08	.04										
24.60	125			12.23	2.65	.81	.30	.13	.07	.03									
29.45	150			17.53	3.80	1.16	.44	.19	.09	.05	.03								
34.44	175				5.17	1.58	.59	.26	.13	.07	.04	.01							
39.35	200				6.77	2.09	.78	.36	.17	.09	.06	.02	.01						
49.20	250				10.61	3.24	1.22	.55	.27	.15	.08	.03	.01						
58.90	300				15.20	4.65	1.78	.78	.38	.21	.12	.05	.02	.01					
68.6	350					6.31	2.37	1.07	.53	.29	.17	.06	.03	.01					
78.6	400					8.28	3.11	1.40	.69	.39	.22	.08	.04	.01					
88.4	450					10.47	3.94	1.77	.88	.48	.28	.11	.05	.02	.01				
98.4	500						4.88	2.20	1.08	.60	.34	.14	.06	.03	.01				
118.1	600						7.03	3.17	1.56	.87	.49	19	.09	.04	.02	.01			
137.5	700						9.52	4.29	2.12	1.17	.67	.27	.12	.06	.03	.02			
156.6	800							5.57	2.75	1.52	.87	.34	.15	.08	.04	.03	.01		
176.5	900							7.08	3.49	1.94	1.17	.43	.19	.09	.05	.03	.01		
196.4	1000							8.77	4.33	2.40	1.37	.54	.24	.12	.06	.04	.02	.01	
294.5	1500								9.73	5.39	3.08	1.20	.55	.27	.15	.09	.03	.01	
393.7	2000									9.65	5.51	2.16	.98	.41	.27	.16	.06	.03	.01
492	2500										8.61	3.36	1.53	.77	.42	.25	.09	.04	.02
589	3000											4.82	2.19	1.11	.61	.36	.14	.06	.03
686	3500											6.54	2.97	1.50	.83	.48	.19	.09	.04
786	4000												3.91	1.98	1.08	.63	.25	.11	.05
884	4500												4.94	2.51	1.36	.79	.32	.15	.07
984	5000												6.19	3.10	1.69	.99	.39	.18	.09
At 80 Pounds Gauge																			
7.74	50	14.31	3.96	1.53	.33	.10	.03	.01											
11.3	75		8.46	3.26	.71	.21	.08	.03	.01										
15.2	100		15.31	5.92	1.28	.39	.14	.06	.03	.02	.01								
19.4	125			9.64	2.09	.64	.24	.11	.05	.03	.01								
23.2	150			13.79	2.99	.91	.34	.15	.07	.04	.02	.01							
27.2	175				4.09	1.25	.47	.21	.10	.06	.03	.01							
31.0	200				5.34	1.63	.61	.27	.13	.07	.04	.01							
38.7	250				8.32	2.54	.96	.43	.21	.12	.07	.02	.01						
46.5	300				12.01	3.67	1.38	.62	.30	.17	.09	.03	.01						
54.2	350					4.99	1.88	.84	.41	.23	.13	.05	.02	.01					
62.0	400					6.53	2.45	1.11	.54	.30	.17	.06	.03	.01					
69.7	450					8.25	3.13	1.40	.69	.38	.22	.08	.04	.01					
77.4	500					10.81	3.83	1.73	.85	.47	.27	.10	.05	.02	.01				
92.9	600						5.61	2.46	1.22	.68	.39	.15	.06	.03	.02	.01			
108.2	700						7.46	3.37	1.66	.92	.53	.20	.09	.04	.02	.01			
124.0	800						9 86	4.42	2.18	1.19	.69	.27	.12	.06	.03	.02	.01		
139.5	900							5.61	2.77	1.54	.88	.34	.15	.08	.04	.02	.01		
152	1000							6.64	3.29	1.82	1.04	.40	.18	.09	.05	.03	.01		
232	1500							15.41	7.62	4.24	2.43	.95	.43	.22	.12	.06	.02	.01	
310	2000								13.62	7.58	4.32	1.69	.77	.39	.21	.12	.04	.02	.01
387	2500									11.79	6.88	2.64	1.19	.60	.33	.19	.07	.03	.01
465	3000										9.72	3.79	1.73	.87	.48	.28	.11	.05	.02
542	3500										13 25	5.27	2.35	1.19	.65	.37	.15	.06	.03
620	4000											6.78	3.07	1.55	.85	.49	.19	.09	.04
697	4500											8.54	3.89	1.97	1.08	.66	.25	.11	.05
774	5000											10.55	4.79	2.46	1.33	.77	.30	.14	.07

For longer or shorter pipes the friction loss is proportional to the length, *i.e.*, for 500 feet ½ of the above, for 4,000 feet four times the above, etc.

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Delivery in Cu. Ft. of Compressed Air per Min.	Equiv. Delivery in Cu. Ft. of Free Air per Min.	Size of Pipe, Inches: 1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	16
		Loss of Pressure, in Pounds, by Friction in 1000 Feet Lengths of Pipe																	
At 100 Pounds Gauge																			
6.41	50	11.89	3.29	1.28	.27	.08	.03	.01											
9.61	75		7.42	2.87	.62	.19	.07	.03	.01										
12 81	100		13.20	5.11	1.15	.34	.12	.05	.02	.01									
15.81	125			7.75	1.68	.52	.19	.08	.04	.02	.01								
19.22	150			11.42	2.48	.76	.29	.13	.06	.03	.02	.01							
22.39	175				3.36	1.03	.39	.17	.09	.04	03	.01							
25.62	200				4.43	1.36	.51	.23	.12	.06	.04	.02	.01						
31.62	250				6.72	2.06	.77	.35	.17	.09	.05	.02	.01						
38.44	300				9.95	3.04	1.14	.51	.25	.14	.08	.03	.01						
44.78	350				13.41	4.11	1.54	.69	.34	.19	.11	.04	.02	.01					
51.24	400					5.40	2.06	.92	.45	.25	.15	.05	.03	.01					
57.65	450					6.85	2.57	1.16	.57	.32	.18	.07	.03	.02	.01				
63.24	500					8.21	3.08	1.39	.68	.38	.22	.08	.04	.02	.01				
76.88	600					12.21	4.58	2.14	1.03	.57	.33	.12	.05	.03	.02	.01			
89.56	700						6.19	2.79	1.38	.77	.44	.17	.07	.04	.02	.01			
102.5	800						8.13	3.67	1.81	1.00	.57	.22	.10	.05	.03	.02	.01		
115.3	900						10.23	4.64	2.29	1.27	.76	.28	.13	.06	.04	.02	.01		
126.5	1000						12.39	5.00	2.76	1.23	.88	.34	.16	.08	.04	.03	.01		
192.2	1500							12.81	6.68	3.51	2.03	.78	.36	.18	.09	.05	.02	.01	
256.2	2000								11.35	6.61	3.62	1.41	.67	.33	.18	.10	.04	.02	.01
316.2	2500									9.50	5.51	2.14	.97	.49	.27	.16	.06	.03	.01
384.4	3000									14.04	8.11	3.16	1.44	.76	.39	.23	.19	.04	.02
447.8	3500										10.95	4.26	1.93	.98	.53	.31	.12	.05	.03
512.4	4000										14.48	5.59	2.55	1.30	.72	.41	.16	.07	.04
576.5	4500											7.04	3.22	1.84	.89	.52	.21	.09	.05
632.4	5000											8.51	3.88	1.93	1.07	.63	.25	.11	.08
At 125 Pounds Gauge																			
5.26	50	9.88	2.70	1.05	.23	.07	.03	.01											
7.89	75	22.20	6.07	2.37	.51	.16	.06	.03	.01										
10.51	100	39.50	10.82	4.22	.91	.28	.10	.05	.02	.01									
13.15	125		16.88	6.58	1.42	.43	.16	.07	.04	.02	.01								
15.79	150		24.33	9.47	2.04	.63	.23	.11	.05	.03	.02	.01							
18.41	175		33.05	12.90	2.78	.85	.32	.14	.07	.04	.02	.01							
21.05	200			16.84	3.63	1.11	.42	.19	.09	.05	.03	.01							
26.30	250			26.30	5.68	1.73	.65	.29	.15	.08	.05	.02	.01						
31.58	300			37.90	8.18	2.51	.94	.42	.21	.12	.07	.03	.01						
36.81	350				11.08	3.39	1.27	.58	.28	.16	.09	.04	.02	.01					
42.10	400				14.51	4.44	1.67	.75	.37	.21	.12	.05	.02	.01					
47.30	450				18.38	5.61	2.11	.95	.47	.26	.15	.06	.03	.01	.01				
52.60	500				22.68	6.95	2.61	1.18	.58	.32	.18	.07	.03	.02	.01				
63.20	600					10.00	3.76	1.69	.84	.46	.27	.10	.05	.02	.01	.01			
73.70	700					13.60	5.11	2.31	1.14	.63	.36	.14	.06	.03	.02	.01			
84.20	800					17.80	6.68	3.01	1.49	.83	.47	.18	.08	.04	.02	.01	.01		
94.70	900						8.45	3.81	1.88	1.04	.60	.23	.11	.05	.03	.02	.01		
105.1	1000						10.42	4.71	2.32	1.29	.74	.29	.13	.07	.04	.02	.01		
157.9	1500						23.48	10.59	5.23	2.90	1.65	.64	.29	.15	.08	.05	.02	.01	
210.5	2000							18.81	9.30	5.15	2.94	1.15	.52	.26	.15	.08	.03	.02	.01
263.0	2500							29.40	14.52	8.05	4.60	1.80	.82	.41	.23	.13	.05	.02	.01
315.8	3000								20.90	11.59	6.63	2.59	1.18	.60	.33	.19	.07	.03	.02
368.1	3500								28.51	15.78	9.01	3.53	1.61	.81	.45	.26	.10	.04	.02
422.0	4000									20.61	11.80	4.61	2.19	1.06	.58	.34	.13	.06	.03
473.0	4500									26.10	14.90	5.83	2.65	1.34	.73	.43	.17	.08	.04
526.0	5000									32.20	18.45	7.20	3.27	1.65	.90	.53	.21	.10	.05

For longer or shorter pipes the friction loss is proportional to the length, *i.e.*, for 500 feet ½ of the above: for 4,000 feet four times the above, etc.

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COMPRESSED AIR DATA

In theory there are two ideal methods of compressing and utilizing air, adiabatically or isothermally.

Adiabatic compression and utilization means that the air is compressed and expanded without transmission of heat to or from the gas.

Isothermal compression and utilization means that the air is compressed and expanded with the addition or rejection of sufficient heat to maintain the air at a constant temperature.

Single Stage Compression

The table shows the horse power required under the conditions named to compress one cubic foot of free air per minute to different gauge pressures by single stage compression.

In columns five and eight of the table below are shown the theoretical horsepowers required for isothermal and adiabatic compression. The results of isothermal compression are wholly unattainable in practice, and are placed here only for purposes of comparison. They represent an ideal which it is desirable always to keep in view. The figures given in the column of adiabatic compression are based on the assumptions that there is no radiation of heat from the air cylinder, and that the temperature of the air after delivery had become normal its volume being therefore reduced to that which is practically available for use. No allowances are included in these figures to cover losses other than that due to the heating of the air compression. But the full amount of loss represented by adiabatic compression can never be suffered in the operation of compressors, however imperfect their design. The actual compression line must always be lower than the adiabatic line, because of the radiation of heat through the cylinder walls. In ordinary, single-stage compressors, properly water-jacketed and run at a reasonable piston speed, the compression line falls considerably below the adiabatic line. Whatever diminution of loss is effected by cooling of the air in the cylinder may therefore be credited against the other unavoidable losses, partially offsetting them, viz: fractional or mechanical loss in the compressor, friction of inlet valves, heating of the intake air by contact with the hot metal surfaces and piston clearance of the cylinder. These losses are variable in amount depending on the design of the compressor.

In the absence of indicator cards giving the actual results in individual cases, estimates based on practice may be made of the net power loss experienced in operating compressors, which will be convenient for reference. With this understanding, an attempt is made in column nine of the table to show the actual horse power required to compress one cubic foot of free air, under the condition stated at top of the column. Fifteen per cent is assumed as a fair estimate in case of well designed and operated single stage compressors of the additional power required, over and above that for theoretical adiabatic compression; this fifteen per cent being taken as: the loss in purely adiabatic compression minus the effect of ordinary water-jacket cooling, plus the other three losses mentioned at end of preceding paragraph.

The figures in columns five, eight and nine (which are for free air), if multiplied by the corresponding ratios of compression (Column 3), will give the respective theoretical and actual power costs of furnishing one cubic foot of compressed air, at the gauge pressure stated.

HORSE-POWER REQUIRED

For Compressing One Cubic Foot of Free Air Per Minute (Isothermally and Adiabatically) From Atmospheric Pressure (14.7 Pounds) to Various Gauge Pressures

Single-Stage Compression

Initial Temperature of Air Taken as 60° F.—Jacket-Cooling Not Considered

Gauge Pressure Pounds	Absolute Pressure Pounds	Number of Atmospheres	Isothermal Compression		Adiabatic Compression			
			Mean Effective Pressure	H. P.	Mean Effective Pressure Theoretical	Mean Eff. Pressure plus 15% Friction	H. P. Theoretical	H. P. plus 15% Friction
5	19.7	1.34	4.13	0.018	4.46	5.12	0.019	0.022
10	24.7	1.68	7.57	0.033	8.21	9.44	0.036	0.041
15	29.7	2.02	11.02	0.048	11.46	13.17	0.050	0.057
20	34.7	2.36	12.62	0.055	14.30	16.44	0.062	0.071
25	39.7	2.70	14.68	0.064	16.94	19.47	0.074	0.085
30	44.7	3.04	16.30	0.071	19.32	22.21	0.084	0.096
35	49.7	3.38	17.90	0.078	21.50	24.72	0.094	0.108
40	54.7	3.72	19.28	0.084	23.53	27.05	0.103	0.118
45	59.7	4.06	20.65	0.090	25.40	29.21	0.111	0.127
50	64.7	4.40	21.80	0.095	27.23	31.31	0.119	0.136
55	69.7	4.74	22.95	0.100	28.90	33.23	0.126	0.145
60	74.7	5.08	23.90	0.104	30.53	35.10	0.133	0.153
65	79.7	5.42	24.80	0.108	32.10	36.91	0.140	0.161
70	84.7	5.76	25.70	0.112	33.57	38.59	0.146	0.168
75	89.7	6.10	26.62	0.116	35.00	40.25	0.153	0.175
80	94.7	6.44	27.52	0.120	36.36	41.80	0.159	0.182
85	99.7	6.78	28.21	0.123	37.63	43.27	0.164	0.189
90	104.7	7.12	28.93	0.126	38.89	44.71	0.169	0.195
95	109.7	7.46	29.60	0.129	40.11	46.12	0.175	0.201
100	114.7	7.80	30.30	0.132	41.28	47.46	0.180	0.207
110	124.7	8.48	31.42	0.137	43.56	50.09	0.190	0.218
120	134.7	9.16	32.60	0.142	45.69	52.53	0.199	0.229
130	144.7	9.84	33.75	0.147	47.72	54.87	0.208	0.239
140	154.7	10.52	34.67	0.151	49.64	57.08	0.216	0.249
150	164.7	11.20	35.59	0.155	51.47	59.18	0.224	0.258
160	174.7	11.88	36.30	0.158	53.70	61.80	0.234	0.269
170	184.7	12.56	37.20	0.162	55.60	64.00	0.242	0.278
180	194.7	13.24	38.10	0.166	57.20	65.80	0.249	0.286
190	204.7	13.92	38.80	0.169	58.80	67.70	0.256	0.294
200	214.7	14.60	39.50	0.172	60.40	69.50	0.263	0.303

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Two and Three Stage Compression

The horse power for two and three stage compression at sea-level, both theoretical and actual, are given in the following tables, the figures in the column headed "Horse power plus 150% friction," being taken as an approximation to the results obtainable in practice from stage compressors of the usual design.

HORSE-POWER REQUIRED

For Compressing One Cubic Foot of Free Air Per Minute (Isothermally and Adiabatically) From Atmospheric Pressure (14.7 Pounds) to Various Gauge Pressures

Two-Stage Compression

Initial Temperature of Air Taken as 60° F.—Jacket-Cooling Not Considered

Gauge Pressure Pounds	Absolute Pressure Pounds	No. of Atmospheres	Correct Ratio of Cylinder Volumes	Intercooler Gauge Pressure	Isothermal Compression		Adiabatic Compression				Percentage of Saving over One-stage Comp
					Mean Eff. Pressure	H. P.	Mean Eff. Pressure Theoretical	Mean Eff Pressure plus 15% Friction	H. P. Theoretical	H. P. plus 15% Friction	
50	64.7	4.40	2 10	16.2	21.80	0.095	24.30	27.90	0.106	0.123	10.9
60	74.7	5.08	2.25	18.4	23.90	0.104	27.20	31.30	0.118	0.136	11.3
70	84.7	5.76	2.40	20.6	25.70	0.112	29.31	33.71	0.128	0.147	12.3
80	94.7	6.44	2.54	22.7	27.52	0.120	31.44	36.15	0.137	0.158	13.8
90	104.7	7.12	2.67	24.5	28.93	0.126	33.37	38.36	0.145	0.167	14.2
100	114.7	7.80	2.79	26.3	30.30	0.132	35.20	40.48	0.153	0.176	15.0
110	124.7	8.48	2.91	28.1	31.42	0.137	36.82	42.34	0.161	0.185	15.2
120	134.7	9.16	3.03	29.8	32.60	0.142	38.44	44.20	0.168	0.193	15.6
130	144.7	9.84	3.14	31.5	33.75	0.147	39.86	45.83	0.174	0.200	16.3
140	154.7	10.52	3.24	32.9	34.67	0.151	41.28	47.47	0.180	0.207	16.7
150	164.7	11.20	3.35	34.5	35.59	0.155	42.60	48.99	0.186	0.214	16.9
160	174.7	11.88	3.45	36.1	36.30	0.158	43.82	50.39	0.191	0.219	18.4
170	184.7	12.56	3.54	37.3	37.20	0.162	44.93	51.66	0.196	0.225	19.0
180	194.7	13.24	3.64	38.8	38.10	0.166	46 05	52.95	0.201	0.231	19.3
190	204.7	13.92	3.73	40 1	38.80	0.169	47.16	54.22	0.206	0.236	19.5
200	214.7	14.60	3.82	41.4	39.50	0.172	48.18	55.39	0.210	0.241	20.1
210	224 7	15.28	3.91	42.8	40.10	0.174	49.35	56.70	0.216	0.247	
220	234.7	15.96	3.99	44.0	40.70	0 177	50.30	57.70	0.220	0.252	
230	244.7	16.64	4.08	45.3	41.30	0.180	51.30	59.10	0.224	0.257	
240	254.7	17.32	4.17	46.6	41.90	0.183	52.25	60.10	0.228	0.262	
250	264.7	18.00	4.24	47.6	42.70	0.186	52.84	60.76	0.230	0.264	
260	274.7	18.68	4.32	48.8	43.00	0.188	53.85	62.05	0.235	0.270	
270	284.7	19.36	4.40	50.0	43.50	0.190	54.60	62.90	0.238	0.274	
280	294.7	20.04	4.48	51.1	44.00	0.192	55.50	63.85	0.242	0.278	
290	304.7	20.72	4.55	52.2	44.50	0.194	56.20	64.75	0.246	0.282	
300	314.7	21.40	4.63	53.4	45.30	0.197	56.70	65.20	0.247	0.283	
350	364.7	24.80	4.98	58.5	47.30	0.206	60.15	69.16	0.262	0.301	
400	414.7	28.20	5.31	63.3	49.20	0.214	63.19	72.65	0.276	0.317	
450	464.7	31.60	5.61	67.8	51.20	0.223	65.93	75.81	0.287	0.329	
500	514.7	35.01	5.91	72.1	52.70	0.229	68.46	78 72	0.298	0.342	

HORSE-POWER REQUIRED

For Compressing One Cubic Foot of Free Air Per Minute (Isothermally and Adiabatically) From Atmospheric Pressure (14.7 Pounds) to Various Gauge Pressures

Three-Stage Compression

Initial Temperature of Air Taken as 60° F.—Jacket-Cooling Not Considered

Gauge Pressure Pounds	Absolute Pressure Pounds	No. of Atmospheres	Correct Ratio of Cylinder Volumes	Intercooler Gauge Pressures		Isothermal Compression		Adiabatic Compression				Percentage Saving over 2-Stage Comp.
				First Stage	Second Stage	Mean Eff. Pressure	H. P	Mean Eff. Pressure Theoretical	Mean Effective Pressure plus 15% Friction	H. P. Theoretical	H. P. plus 15% Friction	
100	114.7	7.8	1.98	14.4	42.9	30.30	0.132	33.30	38.30	0.145	0.167	5.23
150	164.7	11.2	2.24	18.2	59.0	35.59	0.155	40.30	46.50	0.175	0.202	5.92
200	214.7	14.6	2.44	21.2	73.0	39.50	0.172	45.20	52.00	0.196	0.226	6.67
250	264.7	18.0	2.62	23.8	86.1	42.70	0.186	49.20	56.60	0.214	0.246	6 96
300	314.7	21.4	2.78	26.1	98 7	45.30	0.197	52.70	60.70	0.229	0.264	7.28
350	364.7	24.8	2.92	28.2	110.5	47.30	0.206	55.45	63.80	0.242	0.277	7.64
400	414.7	28.2	3.04	30.0	121.0	49.20	0.214	58.25	66.90	0 253	0.292	8.33
450	464.7	31.6	3.16	31.8	132.3	51.20	0.223	60.40	69.40	0 263	0.302	8.36
500	514.7	35.0	3.27	33.4	142.4	52.70	0.229	62.30	71.70	0.273	0 314	8.38
550	564.7	38.4	3.38	35.0	153.1	53.75	0.234	65.00	74.75	0.283	0 326	8.80
600	614.7	41.8	3.47	36.3	162.3	54.85	0.239	66.85	76.90	0.291	0.334	8.86
650	664.7	45.2	3.56	37.6	171.5	56.00	0.244	67.90	78.15	0.296	0.340	9.02
700	714.7	48.6	3.65	38.9	180.8	57.15	0.249	69.40	79.85	0.303	0.348	9.18
750	764 7	52.0	3.73	40.1	189.8	58.10	0.253	70.75	81.40	0.309	0.355	
800	814.7	55.4	3.82	41.4	199.5	59.00	0.257	72.45	83.25	0.315	0.362	
850	864 7	58.8	3.89	42.5	207.8	60 20	0.262	73.75	84.90	0.321	0.369	
900	914 7	62.2	3.95	43.4	214 6	60 80	0.265	74.80	86.00	0.326	0.375	
950	964.7	65.6	4.03	44.6	224.5	61.72	0.269	76.10	87.50	0.331	0.381	
1000	1014.7	69.0	4.11	45.7	233.3	62.40	0.272	77.20	88.80	0.336	0 383	
1050	1064.7	72.4	4:15	46.3	238.3	63.10	0.275	78.10	90.10	0.340	0 391	
1100	1114.7	75.8	4.23	47.5	248.3	63 80	0.278	79.10	91.10	0.344	0.396	
1150	1164.7	79.2	4.30	48.5	256.8	64 40	0.281	80.15	92.20	0 349	0 401	
1200	1214 7	82.6	4.33	49.0	261.3	65 00	0.283	81 00	93.15	0 353	0 405	
1250	1264.7	86.0	4.42	50.3	272 3	65.60	0.286	82.00	94.30	0 357	0.411	
1300	1314.7	89.4	4.48	51.3	280 8	66 30	0.289	82.90	95.30	0 362	0.416	
1350	1364.7	92.8	4 53	52.0	287.3	66.70	0.291	84.00	96.60	0.366	0.421	
1400	1414.7	96.2	4 58	52.6	293 5	67 00	0 292	84 60	97.30	0 368	0.423	
1450	1464 7	99 6	4.64	53 5	301.5	67 70	0.295	85.30	98.20	0 371	0.426	
1500	1514.7	103.0	4.69	54 3	309 3	68 30	0.298	85 80	98.80	0 374	0.430	
1550	1564 7	106.4	4.74	55 0	317.3	68.80	0.300	86.80	99.85	0.378	0 434	
1600	1614.7	109.8	4.79	55 8	323 3	69.10	0.302	87.60	100.80	0.382	0.438	

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DEFINITIONS OF COMPRESSED AIR TERMS

Upon the recommendation of its Technical Committee the Compressed Air Society has adopted the following definitions of certain compressed air terms in order to eliminate confusion as to their exact meaning.

Displacement—The displacement of an air compressor is the volume displaced by the net area of the compressor piston.

Capacity — The capacity should be expressed in cubic feet per minute and is the actual amount of air compressed and delivered, expressed in free air at intake temperature and at the pressure of dry air at the suction.

Volumetric Efficiency—Volumetric efficiency is the ratio of the capacity to the displacement of the compressor, all as defined above.

Compression Efficiency — Compression efficiency is the ratio of the work required to compress isothermally all the air delivered by an air compressor to the work actually done within the compressor cylinder as shown by indicator cards, and may be expressed as the product of the volumetric efficiency (the intake pressure and the hyperbolic logarithm of the ratio of compression), all divided by the indicated mean effective pressure within the air cylinder or cylinders.

Mechanical Efficiency — Mechanical efficiency is the ratio of the air indicated horse-power to the steam indicated horsepower in the case of a steam driven, and to the brake horsepower in the case of a power driven machine.

Overall Efficiency — Overall efficiency is the product of the compression efficiency and the mechanical efficiency.

The society further recommends that the use of other expressions of efficiency be discontinued.

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HORSE POWER REQUIRED TO COMPRESS AIR

The formula for calculating the horse power required to compress, adiabatically, a given volume of free air to a given pressure is,

$$H. P. = \frac{144\ NPVn}{33{,}000\,(n-1)}\left[\left(\frac{P_3}{P}\right)^{\frac{n-1}{Nn}} - 1\right]$$

In which N = Number of stages in which compression is accomplished.

P = Atmospheric Pressure, lbs. per sq. in.

P_s = Absolute terminal pressure in lbs. per sq. in.

V = Volume of air, in. cu. ft., compressed per minute, at atmospheric pressure.

n = Exponent of the compression curve = 1.41 for adiabatic compression.

For different methods of compression and for one cu. ft. of air per minute, this formula may be simplified as follows:

For one-stage compression:
$H. P. = 0.015\ P\ (R^{0.29} - 1)$

For two-stage compression:
$H. P. = 0.030\ P\ (^{0.145} - 1)$

For three-stage compression:
$H. P. = 0.045\ P\ (R^{0.0975} - 1)$

For four-stage compression:
$H. P. = 0.060\ P\ (R^{0.0725} - 1)$

In these latter formulas $R = \frac{P_s}{P}$ = number of atmospheres to be compressed.

The formula for calculating the horse power required to compress isothermally a given volume of free air to a given pressure is:

$$H. P. = \frac{144\ PV}{33000}\ \text{nap. log.}\ \frac{P_3}{P}$$

Napierian logarithms are obtained by multiplying common logarithms by 2.302585.

CUBIC FEET OF FREE AIR

Required to Run One Drill of Size and at the Pressure Stated.

Gauge Pressure Lbs	Cylinder Diameter of Drill												
	2"	2¼"	2½"	2¾"	3"	3⅛"	3³⁄₁₆"	3¼"	3½"	3⅝"	4¼"	5"	5½"
60	50	60	68	82	90	95	97	100	108	113	130	150	164
70	56	68	77	93	102	108	110	113	124	129	147	170	181
80	63	76	86	104	114	120	123	127	131	143	164	190	207
90	70	84	95	115	126	133	136	141	152	159	182	210	230
100	77	92	104	126	138	146	149	154	166	174	199	240	252

MULTIPLIERS TO DETERMINE CAPACITY OF COMPRESSOR

Required to Operate from 1 to 70 Rock Drills at Altitudes Compared with Sea Level

EXAMPLE—Required the amount of free air necessary to operate thirty 5-inch drills at 9,000 feet altitude, using to operate these drills air at a gauge pressure of 80 pounds per square inch.

From Table above we find, when operating the drills at 80 pounds gauge pressure at sea level, that one 5-inch drill requires 190 cubic feet of free air per minute.

Altitude Above Sea Level Feet	Number of Drills — Multipliers																		
	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	50	60	70
0	1.	1.8	2.7	3.4	4.1	4.8	5.4	6.0	6.5	7.1	8.1	9.5	11.7	13.7	15.8	21.4	25.5	29.4	33.2
1000	1.03	1.85	2.78	3.5	4.22	4.94	5.56	6.18	6.69	7.3	8.34	9.78	12.05	14.1	16.3	22.0	26.26	30.3	34.2
2000	1.07	1.92	2.89	3.64	4.39	5.14	5.78	6.42	6.95	7.60	8.67	10.17	12.52	14 66	16.9	22.9	27.28	31.46	35.52
3000	1.10	1.98	2.97	3.74	4.51	5.28	5.94	6.6	7.15	7.81	8.91	10.45	12.87	15.07	17.38	23.54	28.05	32.34	36.52
4000	1.14	2.05	3.08	3.88	4.67	5.47	6.15	6.84	7.41	8.09	9.23	10.83	13.34	15.62	18.01	24.4	29.07	33 52	37.8
5000	1.17	2.10	3.16	3.98	4.8	5.62	6.32	7.02	7.61	8 31	9.48	11.12	13.69	16.03	18.49	25.04	29.84	34.4	38.84
6000	1.20	2.16	3.24	4.08	4.9	5.76	6.48	7.2	7.8	8.52	9.72	11.4	14.04	16.44	18.96	25.68	30.6	35.4	39.84
7000	1.23	2 21	3.32	4.18	5.04	5.9	6.64	7.38	7 99	8.73	9.96	11.68	14.39	16 85	19.43	26.32	31.36	36.16	40.84
8000	1.26	2.27	3.40	4.28	5.17	6.05	6.8	7.56	8 19	8.95	10.21	11.97	14.74	17.26	19.9	29.96	32.13	37.04	41.83
9000	1.29	2.32	3.48	4.39	5.29	6.19	6.96	7.74	8.38	9.16	10.45	12.26	15.09	17.67	20.38	27.6	32.9	37.92	42.83
10000	1.32	2.38	3.56	4.49	5.41	6.34	7.13	7.92	8.58	9.37	10.69	12.54	15.44	18.08	20.86	28.25	33.66	38.8	43.82
12000	1.37	2.47	3.70	4.66	5.62	6.57	7.4	8.22	8.9	9.73	11.1	13.02	16.03	18.77	21 64	29.32	34.94	40.28	45.48
15000	1.43	2.57	3.86	4.86	5.86	6.86	7.72	8.58	9.3	10.15	11.58	13.58	16.73	19.59	22.59	30.6	36.46	42.04	47.47

From Table opposite we also find that the factor for 30 drills at 9,000 feet altitude is 20.38; multiplying 190 cubic feet by 20.38 gives 3,872 cubic feet air per minute, which is the displacement of a compressor for the above outfit under average conditions, to which must be added pipe line losses, such as friction and leakage.

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TABLE FOR SINGLE COMPRESSION AT ALTITUDES

Altitude in Feet	Barometric Pressure		Per cent. of Efficiency of Air Considering its Volume 100 per cent. at Sea Level		Per cent. Increase in Volume Necessary to give at Altitudes Efficiency Equivalent to Sea Level		Horse Power Required to Compress One Cubic Ft. of Free Air at Different Altitudes (Single Compression)		Per cent. of Power Required to Compress Same Piston Displacement Compared with Sea Level		Per cent. Decrease in Power Required to Compress Same Piston Displacement Compared with Sea Level		Per cent. Increase in Power Required to Compress the Volume of Air at Altitude Equal to a Given Volume at Sea Level	
	Inches of Mercury	Pounds per Square Inch	Gauge 80	Gauge 100	Gauge 80	Gauge 100	Gauge 80	Gauge 100	Gauge 80	Gauge 100	Gauge 80	Gauge 100	Gauge 80	Gauge 100
0	30.00	14.75	100.0	100.0	0.0	0.0	.1585	.1800	100.0	100.0	0.0	0.0	0.0	0.0
1000	28.88	14.20	96.8	96.7	3.3	3.4	.1561	.1773	98.5	98.4	1.5	1.6	1.7	1.8
2000	27.80	13.67	93.8	93.6	6.6	6.8	.1536	.1744	96.9	96.8	3.1	3.2	3.3	3.4
3000	26.76	13.16	90.7	90.5	10.2	10.5	.1512	.1714	95.4	95.2	4.6	4.8	5.1	5.2
4000	25.76	12.67	87.8	87.5	13.9	14.2	.1486	.1685	93.7	93.6	6.3	6.4	6.8	6.9
5000	24.79	12.20	84.9	84.6	17.6	18.2	.1464	.1657	92.4	92.0	7.6	8.0	8.6	8.8
6000	23.86	11.73	82.1	81.7	21.8	22.4	.1438	.1629	90.7	90.5	9.3	9.5	10.6	10.7
7000	22.97	11.30	79.5	78.9	25.7	26.7	.1416	.1599	89.3	88.8	10.7	11.2	12.3	12.6
8000	22.11	10.87	76.9	76.3	30.0	31.0	.1391	.1571	87.7	87.3	12.3	12.7	14.1	14.3
9000	21.29	10.46	74.3	73.7	34.7	35.6	.1369	.1543	86.4	85.7	13.6	14.3	16.2	16.3
10000	20.49	10.07	71.9	71.2	39.0	40.0	.1348	.1515	85.0	84.1	15.0	15.9	18.2	18.8

TABLE FOR TWO-STAGE COMPRESSION AT ALTITUDES

Altitude in Feet	Barometric Pressure		Percentage of Efficiency of Air at Altitudes Considering its Volume 100% at Sea Level				Percentage Increase in Volume Necessary to give at Altitudes Efficiency Equivalent to Sea Level				Horse-Power Required to Compress One Cubic Foot of Free Air to			
	Inches of Mercury	Pounds per Sq. In.	GAUGE PRESSURE 60	80	100	125 150	GAUGE PRESSURE 60	80	100	125 150	GAUGE PRESSURE 60	80	100	125 150
0	30.00	14.75	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	.1175	.1375	.1535	.1708
						96.6				3.5				.1859
1000	28.88	14.20	96.9	96.8	96.7	96.5	3.2	3.3	3.4	3.6	.1157	.1345	.1508	.1675
						93.4				7.0				.1820
2000	27.80	13.67	94.0	93.8	93.6	93.3	6.3	6.6	6.8	7.2	.1143	.1324	.1481	.1641
						90.2				11.0				.1781
3000	26.76	13.16	91.2	90.7	90.5	90.0	9.6	10.2	10.5	11.1	.1116	.1298	.1449	.1607
						87.2				14.6				.1742
4000	25.76	12.67	88.3	87.8	87.5	87.0	13.2	13.9	14.2	14.9	.1097	.1273	.1422	.1574
						84.2				18.7				.1707
5000	24.79	12.20	85.6	84.9	84.6	84.0	16.8	17.6	18.2	19.0	.1079	.1251	.1391	.1541
						81.2				23.1				.1670
6000	23.86	11.73	82.8	82.1	81.7	81.0	20.7	21.8	22.4	23.4	.1059	.1228	.1362	.1510
						78.5				27.4				.1634
7000	22.97	11.30	80.3	79.5	78.9	78.2	24.5	25.7	26.7	27.8	.1040	.1203	.1336	.1478
						75.8				31.9				.1598
8000	22.11	10.87	77.7	76.9	76.3	75.4	28.7	30.0	31.0	32.6	.1020	.1180	.1308	.1445
						73.1				36.8				.1563
9000	21.29	10.46	75.2	74.3	73.7	72.8	32.9	34.7	35.6	37.3	.1003	.1154	.1281	.1415
						70.6				41.6				.1529
10000	20.49	10.07	72.8	71.9	71.2	70.2	37.3	39.0	40.0	42.4	.0984	.1133	.1254	.1384 .1493

EFFICIENCIES OF AIR COMPRESSION AT DIFFERENT ALTITUDES

Altitude	Barometric Pressure		Volumetric Efficiency Compressor Per Cent.	Loss of Capacity Per Cent.	Decreased Power Required Per Cent.
	Inches Mercury	Pounds per Sq. Inch			
0	30.00	14.75	100	0	0.
1000	28.88	14.20	97	3	1.8
2000	27.80	13.67	93	7	3.5
3000	26.76	13.16	90	10	5.2
4000	25.76	12.67	87	13	6.9
5000	24.79	12.20	84	16	8.5
6000	23.86	11.73	81	19	10.1
7000	22.97	11.30	78	22	11.6
8000	22.11	10.87	76	24	13.1
9000	21.29	10.46	73	27	14.6
10000	20.49	10.07	70	30	16.1
11000	19.72	9.70	68	32	17.6
12000	18.98	9.34	65	35	19.1
13000	18.27	8.98	63	37	20.6
14000	17.59	8.65	60	40	22.1
15000	16.93	8.32	58	42	23.5

EFFECT OF ALTITUDE ON VOLUME

Comparative volumes of free air at different altitudes and 60° initial temperature, which, when compressed, will give the same mechanical effect.

Altitude	Gauge Pressure		
	60 lb.	80 lb.	100 lb.
0	1.000	1.000	1.000
5000	1.168	1.178	1.182
10000	1.373	1.394	1.404

HORSEPOWER DEVELOPED

Horse power developed with allowance for usual losses in compressing one cubic foot of free air at 60° from atmospheric (14.7 lbs.) to various pressures.

Altitude	Single Compression			Two-Stage Compression		
	60 lb.	80 lb.	100 lb.	60 lb.	80 lb.	100 lb.
0	.1533	.1824	.2075	.1354	.1580	.1765
5000	.1425	.1685	.1906	.1241	.1438	.1600
10000	.1316	.1547	.1743	.1132	.1303	.1442

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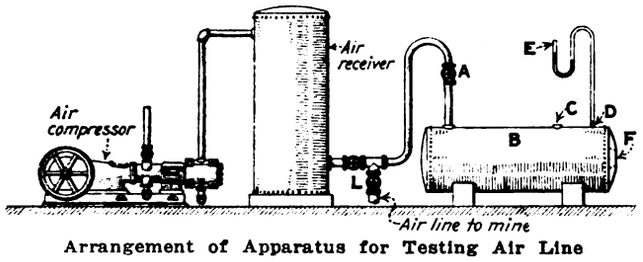
A METHOD FOR MEASURING LEAKAGE IN COMPRESSED AIR LINES

This paper is a discussion of a method for determining the number of cubic feet of free air that leaks from an air line each minute when the receiver pressure is held constant at the usual mine pressure. The measuring device is the low-pressure-orifice meter that is ordinarily used for testing compressors. A sketch of this meter and its connections to the receiver is shown in the figure.

The meter is connected to the receiver in the air-compressor room. The air flows from the receiver through the valve A into the tank B and then out through the orifice F. At the point D the pressure is tapen with a water manometer E. The temperature in the tank is taken with a thermometer at C. The orifice is carefully made with a smooth, rounded inner surface.



Arrangement of Apparatus for Testing Air Line

The leakage is determined as follows: Close the valve L on the air line so that there is no connection between it and the receiver in the compressor room. Select one compressor (if there are several compressors) whose capacity is greater than the leaks. Adjust this compressor so that it will not unload at the pressure at which the test is to be made.

Now, run this compressor and discharge all of the air through the orifice. Adjust valve A until the compressor holds exactly the desired pressure. When the pressure remains constant at this value, a reading of the meter shows how much air the compressor will deliver at that pressure. This amount will be constant as long as the receiver pressure is constant.

Now, open the valve on the air line to the mine. The air line and meter are now in parallel. Adjust valve A until the pressure in the receiver is constant at the desired value. The compressor is now delivering the same amount of air that it was delivering when all was discharged through the orifice, but some of the air is leaking from the air line and the rest is going through the orifice. A reading of the meter shows how much is passing the orifice. The difference between the first reading and this reading is the amount that is leaking from the air line.

Example: The air is measured as free air.

	Cu. Ft. per Minute
Meter reading, all air through orifice	500
Meter reading, meter in parallel with air line	300

Leakage 500 — 300 = 200 cu. ft. per minute.

If the air line is very long, it will take a little time to determine whether the air pressure in the receiver has become constant.

Let it be assumed, for example, that the air line consists of 20,000 ft. of 6-in. pipe and that the receiver in the compressor room has a volume of 1,000 cu. ft. The total capacity will be 5,000 cu. ft.

Let it be further assumed that the value to the orifice has been adjusted so that the compressor will deliver 10 cu. ft. more air each minute than is discharged through the leaks and through the orifice. This excess air will increase the pressure. How long will it take this excess air to increase the pressure 1 lb. per sq. in.? Assume the barometric pressure to be 15 lb. per sq. in. absolute.

$$Vat = \frac{(P_1 - P_2)\ V}{15}$$

For derivation and discussion of this formula see article on "Air Receiver Calculations" in another part of this book.

Vat is the free air necessary to change the pressure.

$(P_1 - P_2)$ is the change in pressure.

V is the volume of the receiver and line.

Units are cubic feet and lb. per sq. in.

$$Vat = \frac{1 \times 5{,}000}{15} = 333$$

Now, if it takes an increase of 333 cu. ft, of free air to change the pressure 1 lb., it will take the excess of 10 cu. ft. per minute thirty-three minutes to produce this change. It will actually take less time than this because the compressor puts hot air into the line, whereas this formula assumes constant temperature.

A good recording gage can be easily read to the nearest pound, and smaller changes can be detected, so in this test if one watches the gage for fifteen minutes one could probably tell whether or not the pressure was constant. Obviously, the larger the air line the longer one must watch the gage.

Suppose the purpose be to determine the leakage in a large underground receiver. First, run a test on the leakage of the line with underground receiver disconnected. Then run a test on the air line and receiver together. The difference in the two amounts of leakage is the leakage in the receiver.

Assume that the volume of the line, the surface receiver, and the underground receiver is 30,000 cu. ft. How long will it take an excess of 10 cu. ft. per minute to raise the pressure 1 lb.?

$$Vat = \frac{1 \times 30{,}000}{15} = 2{,}000$$

It will take the excess about 200 minutes to raise the pressure 1 lb. A change might possibly be detected in an hour.

While a test is being run all conditions must, of course, remain constant. The compressor must run at constant speed and all the valves in the mine must be kept closed.

—By Walter S. Weeks. Written for Eng. and Min. Journal.

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COMPRESSED AIR TABLE FOR HOISTING ENGINES

The following table is intended to give an approximate idea of the volume of free air required for operating hoisting engines, the air being delivered to the engines at 60 pounds gauge pressure. There are so many variable conditions in the operation of hoisting by the hoisting engines in common use that accurate computations can only be offered when fixed data are given. In the table, the hoisting engine is assumed to actually run but one-half of the time for hoisting, while the compressor, of course, runs continuously. If the engine runs less than one-half the time, as it usually does, the volume of air required will be proportionately less, and vice versa. The table is computed for maximum loads, which also in practice may vary widely. From the intermittent character of the work of a hoisting engine the parts are able to resume their normal temperature between the hoists, and there is little probability of the annoyance of freezing up the exhaust passages.

TABLE OF THE VOLUME OF FREE AIR REQUIRED FOR OPERATING HOISTING ENGINES

The Air Compressed to 60 Pounds Gauge Pressure

Diameter of Cylinder Inches	Stroke Inches	R.P.M.	Normal H. P.	Actual H. P.	Weight Lifted Single Rope	Cubic Feet of Free Air Required
Single Cylinder Hoisting Engine						
5	6	200	3	5.9	600	75
5	8	160	4	6.3	1000	80
6¼	8	160	6	9.9	1500	125
7	10	125	10	12.1	2000	151
8¼	10	125	15	16.8	3000	170
8½	12	110	20	18.9	5000	238
10	12	110	25	26.2	6000	330
Double Cylinder Hoisting Engine						
5	6	200	6	11.8	1000	150
5	8	160	8	12.6	1650	160
6¼	8	160	12	19.8	2500	250
7	10	125	20	24.2	3500	302
8¼	10	125	30	33.6	6000	340
8½	12	110	40	37.8	8000	476
10	12	110	50	52.4	10000	660
12¼	15	100	75	89.2	.....	1125
14	18	90	100	125.	.....	1587

AIR REQUIRED TO HOIST ONE TON (2240 POUNDS) OF ROCK AT VARIOUS ANGLES OF SLOPE*

Angles Measured From the Horizontal

Angle of Slope Degrees	Cubic Feet of Free Air Consumed per Minute of Actual Hoisting (speed of rope being 350 feet per minute)	Cubic Feet of Free Air Consumed for Each 100 Feet of Hoist (measured on the slope)
0	11	3.14
5	90	25.7
10	100	45.6
15	230	65.7
20	320	91.2
25	400	114
30	470	134
35	520	148
40	590	168
45	650	186
50	700	200
60	790	225
75	880	250
90	900	257

*Original by F. A. Halsey.

This table includes the power required to hoist the skip and rope and overcome the friction. It assumes that 20 per cent. of the power of the engine is consumed in its own friction and that of the gearing; that the skip weighs one-half as much as its contents; and that the traction on a horizontal mine track is 30 pounds per ton; and it provides for 500 feet of wire rope.

The consumption of air is based on the assumption that the engine is of the plain slide valve pattern, of good construction and in good condition, and that it is loaded to nearly or quite full capacity. It should be remembered that the table gives the consumption of air while the engine is actually in motion. In estimating the consumption per hour, allowance should be made for the time that the engine stands idle. If the compressor is a large one, doing other work—drilling, pumping, etc.—the compressor capacity should be based on the hourly consumption in which allowance is made for the time the hoist stands idle, but if the compressor is driving the hoist alone, it is advisable to consider the hoist as running continuously (whether it really is or not) and figure the compressor on that basis. For a balanced hoist use only the **unbalanced load** in applying this rule. If the engine is not loaded to its full capacity, the air being throttled, it will require more air to do the same work. Decreasing the speed of hoisting will diminish the power developed and the air consumed per minute, but as the time of hoisting is thereby lengthened, the air consumed per hoist will remain unchanged. Increased speed will give a corresponding result.

MULTIPLIERS TO BE USED FOR TRANSFORMING VOLUMES OF COMPRESSED AIR AT VARIOUS PRESSURES INTO CORRESPONDING VOLUMES OF FREE ARI AT ATMOSPHERIC PRESSURE OF 14 7 POUNDS

Pressure, Lbs.	Multiplier	Pressure, Lbs.	Multiplier	Pressure, Lbs.	Multiplier	Pressure, Lbs.	Multiplier	Pressure, Lbs.	Multiplier
1	1.068027	26	2.768602	51	4.469377	76	6.170052	101	7.870727
2	1.136054	27	2.836729	52	4.537404	77	6.238079	102	7.938754
3	1.204081	28	2.904756	53	4.605431	78	6.306106	103	8.006781
4	1.272108	29	2.972783	54	4.673458	79	6.374133	104	8.074808
5	1.340135	30	3.040810	55	4.741485	80	6.442160	105	8.142835
6	1.408162	31	3.108837	56	4.809512	81	6.510187	106	8.210862
7	1.476189	32	3.176864	57	4.877539	82	6.578214	107	8.278889
8	1.544216	33	3.244891	58	4.945566	83	6.646241	108	8.346916
9	1.612243	34	3.312918	59	5.013593	84	6.714268	109	8.414943
10	1.680270	35	3.380945	60	5.081620	85	6.782295	110	8.482970
11	1.748297	36	3.448972	61	5.149647	86	6.850322		
12	1.816324	37	3.516999	62	5.217674	87	6.918349		
13	1.884351	38	3.585026	63	5.285701	88	6.986376		
14	1.952378	39	3.653053	64	5.353728	89	7.054403		
15	2.020405	40	3.721080	65	5.421755	90	7.122430		
16	2.088432	41	3.789107	66	5.489782	91	7.190457		
17	2.156459	42	3.857134	67	5.557809	92	7.258484		
18	2.224486	43	3.925161	68	5.625836	93	7.326511		
19	2.292513	44	3.993188	69	5.693863	94	7.394538		
20	2.360540	45	4.061215	70	5.761890	95	7.462565		
21	2.428567	46	4.129242	71	5.829917	96	7.530592		
22	2.496594	47	4.197269	72	5.897944	97	7.598619		
23	2.564621	48	4.265296	73	5.965971	98	7.666646		
24	2.632648	49	4.333323	74	6.033998	99	7.734673		
25	2.700675	50	4.401350	75	6.102025	100	7.802700		

Formula

$$\frac{1}{14.7} \times \text{Pressure} + 1 = \text{Multiplier}$$

Atm. Press. 14.7 pounds = 30″ Barom. Press. Temp. 60° F.

EFFECT OF INITIAL OR INTAKE TEMEPRATURE ON EFFICIENCY AND CAPACITY OF AIR COMPRESSORS

Unit Capacity and Efficiency Assumed at 60° F.

Initial Temperature		Relative Capacities and Efficiencies	Initial Temperature		Relative Capacities and Efficiencies
Degrees Fahr.	Degrees Abs.		Degrees Fahr.	Degrees Abs.	
−20	441	1.18	70	531	.980
−10	451	1.155	80	541	.961
0	461	1.13	90	551	.944
10	471	1.104	100	561	.928
20	481	1.083	110	571	.912
30	491	1.061	120	581	.896
32	493	1.058	130	591	.880
40	501	1.040	140	601	.866
50	511	1.020	150	611	.852
60	521	1.000	160	621	.838

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THE BROWNELL COMPANY

DAYTON, OHIO

ESTABLISHED 1855

SALES REPRESENTATIVES IN ALL SECTIONS OF THE COUNTRY

Manufacturers of

Engines, Boilers, Feed Water Heaters, and Tanks

Products

Boilers—Horizontal Return Tubular; Locomotive Type Portable; Vertical Tubular; Scotch; Brickset Firebox Heating; Return Flue Portable Heating; Oil Country.

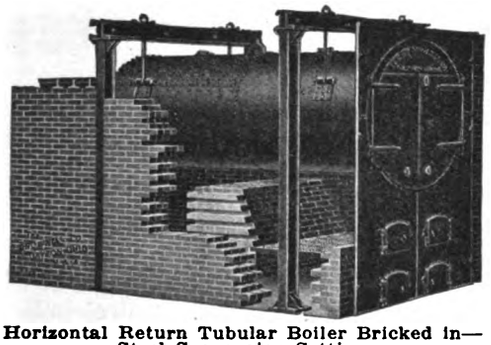
Engines—Automatic; Throttling; Fan; Variable Speed Duplex; Constant Speed; Oil Country Drilling.

Feed Water Heaters—Open; Closed; Tower.

Tanks—Pressure; Storage; and Special Sheet Metal Work.

Brownell Boilers

The Brownell Company, with its sixty-six years of experience gained in the continuous design and construction of boilers and engines and its policy to make only the best, manufactures a complete line of high grade boilers for power and heating purposes. The design, material and workmanship are always consistent with the Company's enviable reputation and policy. The boilers are built according

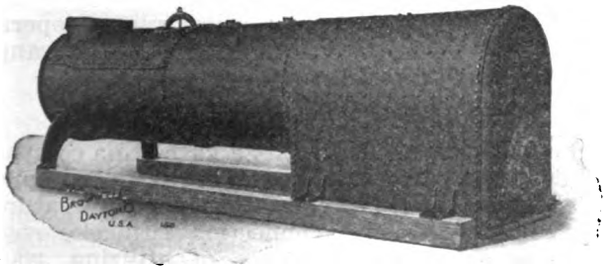


Horizontal Return Tubular Boiler Bricked in—Steel Suspension Setting

to the A. S. M. E. Boiler Code or the laws of the various states and municipalities, and to pass the most rigid inspection requirements.

Horizontal Return Tubular Boilers

This line of power boilers, particularly adapted to mining requirements, are built in units from 15 to 250 H. P. for working pressures up to 150 lbs. Details of the bare boilers together with various types of settings and fronts are found in Bulletin B-1. Steel casing settings, especially economical, which minimize heat losses and maintenance costs, are illustrated and described in Bulletin B-4.



Locomotive Type Portable Boiler on Skids

Locomotive Type Portable Boilers

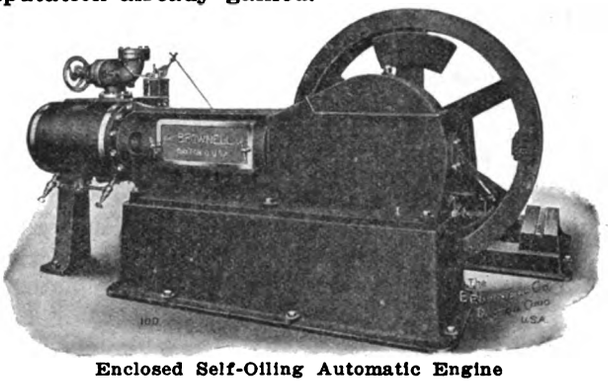
For construction work or for any purpose which requires a high class boiler which is movable, The Brownell Company builds Locomotive Type Portable Boilers. The horse power ratings vary from 15 to 150, for pressures up to 150 lbs. Boilers not larger than 50 H. P. can be mounted on wheels for easy transportation. Send for Bulletin B-2 for specifications.

Feed Water Heaters

The Brownell Company manufactures Open Feed Water Heaters ranging in sizes from 50 to 1500 H. P.; Closed Heaters in sizes from 35 to 1000 H. P.; and Tower Heaters in any required size. For details refer to Bulletin H-1.

Brownell Side Crank Steam Engines

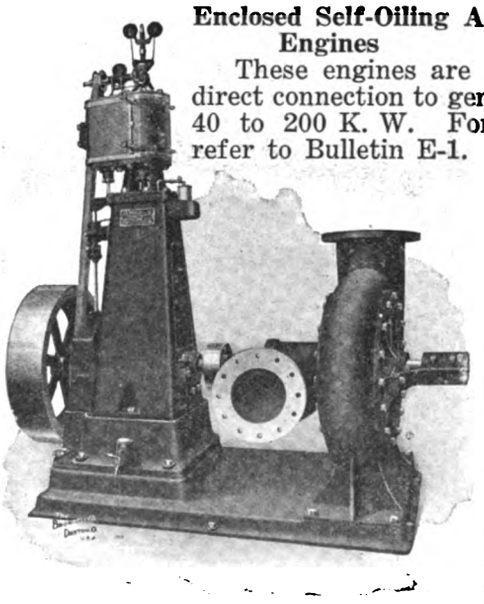
Some of our early engines are still in operation after thirty and forty years of hard service. This is proof of the quality of Brownell engines, and those built today are constructed to maintain the reputation already gained.



Enclosed Self-Oiling Automatic Engine

Enclosed Self-Oiling Automatic Engines

These engines are arranged for direct connection to generators from 40 to 200 K. W. For description refer to Bulletin E-1.



Vertical Enclosed Self-Oiling Engine Direct Connected to Centrifugal Pump

Vertical Enclosed Self-Oiling Engines

These engines are built with either automatic or throttling type of governor for direct connection or belt drive. The engine is equipped with an oil pump and separator which insures excellent lubrication with minimum care. Send for Bulletin E-7.

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EDGE MOOR IRON COMPANY

EDGE MOOR, DEL.

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Designers and Builders of

The Edge Moor Water Tube Boiler

Edge Moor Water Tube Boilers are built to specifications which exceed the requirements of the A. S. M. E. Code, for high-pressure service.

All-Steel Construction

The Edge Moor Boiler, exclusive of handhole plates, is strictly an all-steel boiler. Handhole plates are furnished of forged steel or of cast iron of special construction which is approved under the A. S. M. E. Code. In no other part is cast iron used.

Unrestricted Header and Drum Connection

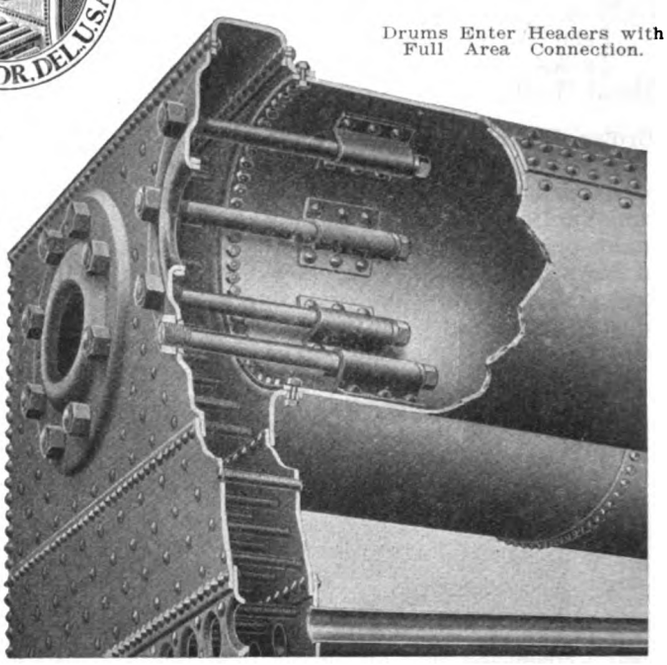
A distinctive feature of the Edge Moor Boiler is the extension of the headers, at full width, well above the drums. Contrary to the usual construction, the drums enter the headers with full area connection, thus providing a much larger throat, as shown in the illustration at the right.

Built-Up Headers

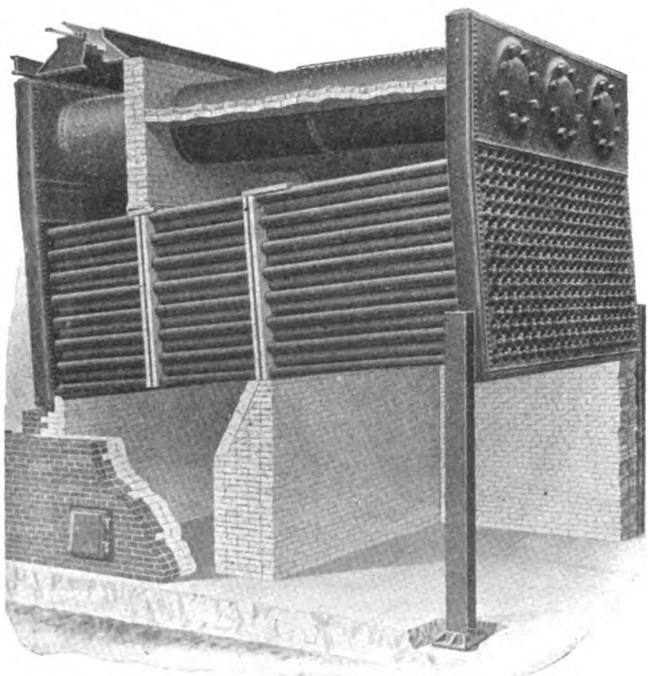
Just as a cable built up of strands of small wire is superior to a solid wire of the same diameter, so are built-up boiler headers far stronger and more reliable than those cast or forged in a single piece. For this reason, all headers used in Edge Moor Boilers are of built-up-construction.

Unique Method of Attaching Drums to Headers

The drums of Edge Moor Boilers are effectively attached to headers through the bulge plates by eight steel bolts, 2½" in diameter, anchored through steel U-plates riveted to inside of drum (see illustration). Joint in header plate is made permanently tight by an annealed copper cone-nut which is drawn into conical hole in plate by screwing up on outside nut before stay bolt is anchored.



Drums Enter Headers with Full Area Connection.



Note Header Construction, Horizontal Drums, Straight, Inclined Tubes, and Efficient Cross Baffling

All Handholes Elliptical

Every handhole in the Edge Moor Boiler is elliptical, thus making it possible to pass every cover through its own handhole, instead of from one hole to another, as must be done with most boilers.

This Edge Moor feature considerably reduces the cost of labor when opening and closing boiler for cleaning or inspection.

Varied Types of Baffling

The baffling in Edge Moor Boilers can be supplied in a variety of combinations to meet individual conditions, and for use with any type of stoking or combustion device. We will gladly co-operate with you in jointly working out the best arrangement for any particular installation.

Waste Heat Boilers

For the utilization of waste gases this company has developed an adaptation of its standard boiler, which contains all the special Edge Moor features. This boiler, operated in connection with coke ovens, provides an effective means of utilizing waste heat.

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The Walsh & Weidner Boiler Company

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Branch Sales Offices

NEW YORK	NEW ORLEANS	SAN FRANCISCO	JACKSONVILLE
HAVANA	MEMPHIS	KANSAS CITY	CHICAGO

Manufacturers of

Boilers, Tanks and Towers, Storage Tanks, Structural Steel and Steel Plate Work of All Descriptions

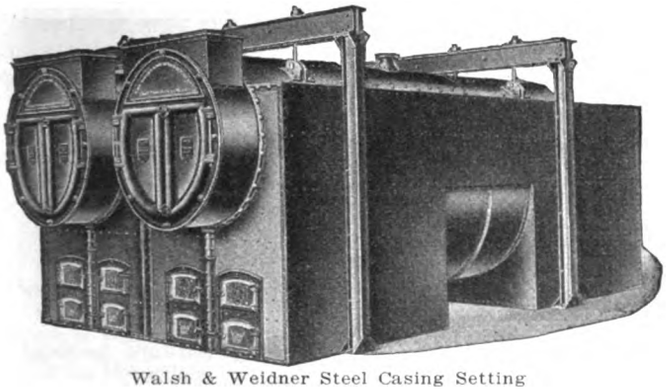
Products

Walsh & Weidner Horizontal Return Tubular Boiler; Water Tube Boilers of all types; Storage and Pressure Tanks; Towers and Tanks; Structural Steel Work.

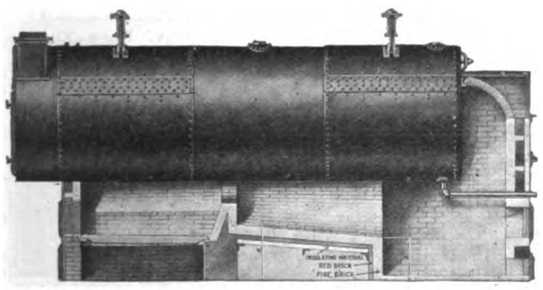
Also Inclined, Horizontal and Cross Drum Water Tube Boilers; Internal Furnace Locomotive Type Portable Boilers; Vertical Tubular Boilers; Standpipes; Smokestacks; Steel Breechings; Plate Steel Work.

Return Tubular Boilers

Walsh & Weidner Return Tubular Boilers are built in one of the largest and most modern plants, by the best of skilled labor, in accordance with the most modern practice, and are designed to suit the peculiar needs and conditions under which they operate. All boilers are built to conform to the requirements of the American Society Mechanical Engineers Code, and under the personal supervision of a Hartford Steam Boiler Inspection and Insurance Company Inspector.



Walsh & Weidner Steel Casing Setting



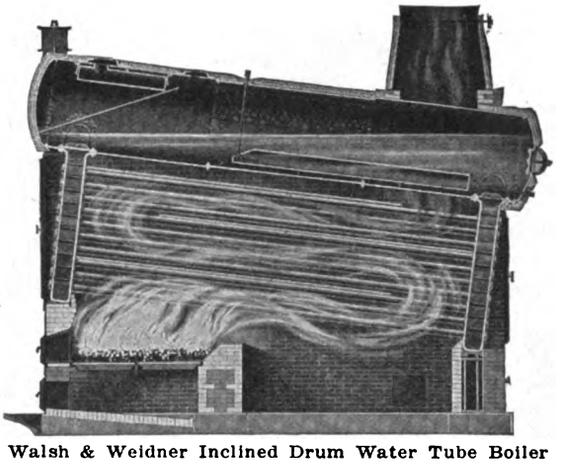
Sectional View of Casing Showing Barrel and Drop Combustion Chamber

Steel Casings

Steel Casings are big money savers for either Return Tubular or Water Tube boiler settings. They not only cut down to the minimum the air leakage, but reduce the total boiler floor space and make a much neater and cleaner installation, increasing for many years the life of the boiler setting and at the same time decreasing the maintenance expense.

Water Tube Boilers

The layout of the tubes and inclined baffles used in the Walsh & Weidner Water Tube Boilers insures positive circulation and makes the heating surface operative. This results in a boiler that can be operated at 250 to 300% normal rating, if fuels and stokers are properly installed with minimum draft losses. Boilers and Furnaces are designed for all conditions and classes of fuel.



Walsh & Weidner Inclined Drum Water Tube Boiler

Plate and Structural Work

This company is especially well prepared to furnish and erect tanks, plate steel and structural steel work of any description, and maintains a large experienced erection force prepared to erect material of this kind in any part of the country. A large efficient corps of engineers capable of designing and preparing plans are always at your service.

Catalogs

Specialized booklets covering boilers and tanks gladly sent on request.

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Los Angeles.....Van Nuys Bldg.
New Orleans, Whitney Central Bk. Bldg.
Philadelphia.....Bulletin Bldg.
St. Louis.....Railway Exchange Bldg.
Buffalo.....Mutual Life Bldg.
Cleveland.....Bulkley Bldg.
Detroit.....Book Bldg.

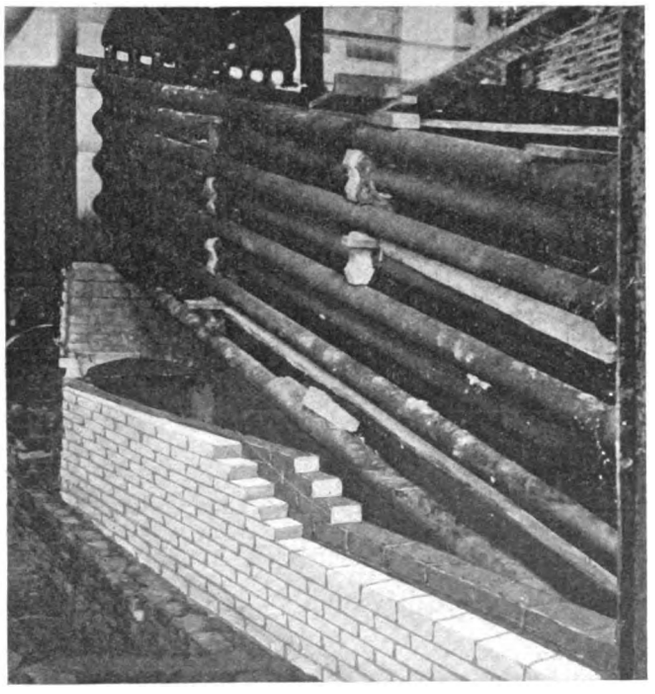
Products

Sil-O-Cel Brick, Block, Powder and Cements for heat insulation. Celite High Temperature Cements for laying, facing and patching fire brick settings.

General Description

Sil-O-Cel Insulation prevents heat loss due to the radiation of heat through the walls, settings and tops of all types of heated equipment. It is used as an insulating backing for the refractory lining and is laid up between the fire brick and outer walls.

Tests of the insulating value of Sil-O-Cel prove it to be less than one-tenth as conductive as fire brick, inch for inch. It is unaffected by temperatures which completely destroy other forms of insulation and where necessary can be supplied in forms which withstand direct heats of 2200° F. Sil-O-Cel does not melt until 2930° F.; it is sufficiently compressible and elastic to take up the strains due to expansion and contraction; it will not fuse, settle or shrink when placed against the highly heated refractory lining.



Sil-O-Cel Brick Insulation Construction of Boilers

Advantages

Sil-O-Cel Insulation prevents heat waste and reduces fuel consumption.

It increases output by making productive the heat which is ordinarily lost in uninsulated equipment.

It secures a more uniform distribution of temperature.

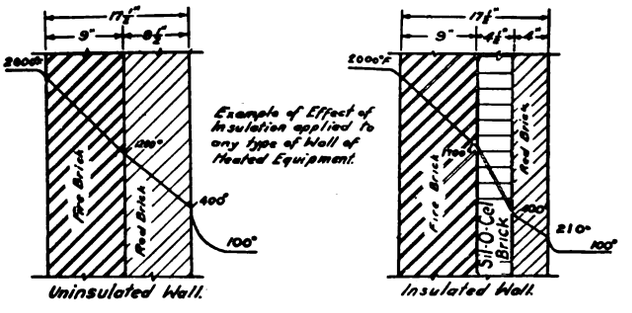
It makes possible more accurate control of temperature.

It protects the outer shells from temperature strains.

It improves working conditions.

Boiler Insulation

The efficiency of a boiler depends on the differential temperature between the water in the boiler and flue gases and the amount of radiant energy given off by the fuel bed and luminous flames. The amount of heat radiated from a boiler setting is usually given by authorities as small and is, therefore, many times disregarded. The actual loss, however, is high, since the loss of heat lowers the differential temperature and hence the boiler efficiency, because heat cannot be absorbed effectively from boiler flue gases which are colder than from 500° to 600° F. Radiant energy is absorbed most readily by the boiler, since it requires no material agency for its propagation and does not depend on convection; but this radiant energy is absorbed by the brick work as well as the boiler and is lost by radiation from the settings, unless measures are taken to prevent it.



Fuel Losses per 1000 Sq Ft per hr. of Radiating Surface.

Wall	Fuel	Loss per hour per hr.	Lbs Coal Loss/hour #	Gals. oil Loss/hour #	Cu. Ft. Gas Loss/hour #	Calorific Value
Uninsulated	Coal	600,000 BTU	50.0			12000 BTU/lb
Insulated	"	220,000 "	18.3			" " "
Uninsulated	Oil	600,000 "		4.1		145000 " /gal
Insulated	"	220,000 "		1.5		" " "
Uninsulated	Gas	600,000 "			1000	600 BTU/cu ft
Insulated	"	220,000 "			366	" " "

Diagram Showing Heat Flow and Fuel Loss Through Insulated and Uninsulated Walls

Tests of Insulation Savings

Tests of insulated and uninsulated equipment prove the saving secured through Sil-O-Cel. With an internal temperature of 2,000 degrees F. and a room temperature of 100 degrees F. the exterior of an uninsulated wall showed a temperature of 400 degrees, whereas the temperature of the exterior of the insulated wall was only 210 degrees.

This difference of 190 degrees corresponds to a saving through Sil-O-Cel insulation of 31.7 pounds of coal, 2.6 gallons of oil, of 634 cubic feet of natural gas for each thousand square feet of radiating surface each hour.

Engineering Service

An engineering department is maintained for the purpose of providing additional data on any specific heat insulating problem which may confront you, and the services of our technical staff are available at all times without cost or obligation. Address the nearest office, given above.

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Quigley Furnace Specialties Company, Inc.

General Offices: 26 Cortlandt Street, NEW YORK, N. Y.

Branch Offices
CHICAGO
105 W. Monroe St.
PHILADELPHIA
638 Real Estate Trust Bldg.

Factories
JAMAICA, N. Y., FREDERICKSBURG, VA.
Distributors for Pittsburgh District—Colonial Supply Co.
Representatives in 64 Cities in the United States and Canada

Cable Address:
"QUIGLECO"
Code Used:
WESTERN UNION, 5 LETTER

Products

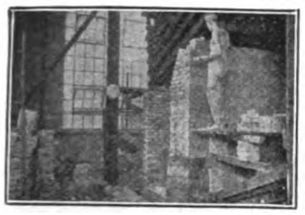
Hytempite—A Refractory Cement for bonding silica and fire clay brick, and for kindred uses.

Carbosand—A highly Refractory Granular Material for making rammed-in linings, special tile, patches and repairs in furnace structures.

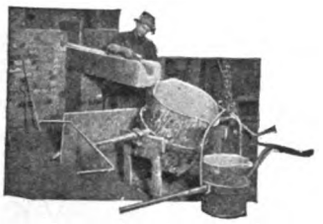
High Temperature Insulation—Made in Brick, Block, Powder and Cement Form for retarding heat flow through boiler and furnace walls, stills, ovens and similar equipment.

Hytempite

A high temperature furnace cement which forms a lasting union between materials to be



Hytempite for Boiler Settings



Hytempite for Cupolas and Ladles

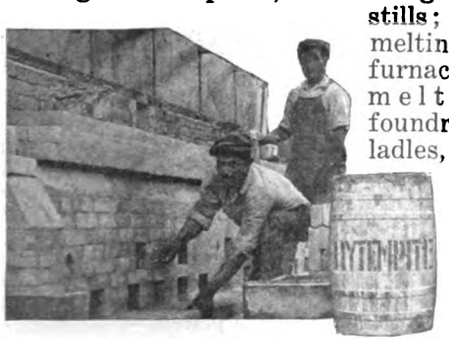
joined. It sets at normal temperatures and retains its strength up to temperatures at which the best quality of brick loses its strength and becomes soft.

Forms in Place, Reverberatory Smelting Furnace, Ready for Lining

Ramming-in Lining, Smelting Furnace

Hytempite, when used in place of fire clay for laying up brickwork, greatly adds to the life of the structure.

It is successfully used for furnace and boiler settings and repairs; for setting tile, retorts, oil stills; lining metal melting furnaces, pit furnaces, open flame melting furnaces, foundry cupolas and ladles, and as a core wash.

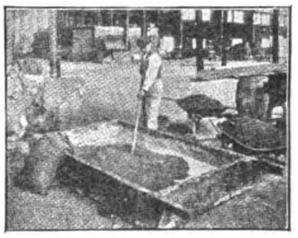


Laying Up Furnace Lining with Hytempite

Tests have proven that Hytempite used as a binder, when air-set, forms a joint as strong as the refractory material united, and that the strength is not impaired but increased by the action of heat. This property makes a wall or structure impossible to obtain with fire clay, or other materials which depend on heat to effect a bond or vitrification.

Hytempite withstands the cutting action of flames and is especially recommended for oil furnaces where the gases are usually of high velocity.

Hytempite can be used as a coating or wash, or to smoothen and harden the surface of a furnace lining to protect it from abrasion, etc.



Mixing Refractory Materials with Hytempite for Rammed-in Linings

Hytempite can be used wherever fire brick or tile are used.

Carbosand

A highly refractory fire sand made in the electric furnace by fusing at high temperature a mixture of natural silica in its purest form and petroleum coke. Owing to its highly refractory nature it is an ideal material for use where the scouring action or flame or hot gases attack a lining.

Patching Boiler Settings

It is used for making rammed-in linings, special shapes, tile and repairs, and for surfacing walls of furnaces or other structures subject to severe flame action.

Furnace door repaired with Hytempite.

Standard Size Insulbrix

High Temperature Insulation

These products possess exceptional heat insulating qualities and are specially adapted for heat conservation at high temperatures.

Standard Insulbrix—9x4½x2½ in.; weight approximately 2⅔ lb., or about one-third the weight of ordinary fire brick. The conductivity of Insulbrix is extremely low: 1 in. of Insulbrix being equal in insulating value to six to ten times the same thickness of fire brick or red brick, depending on conditions such as furnace temperature, conductivity of other brick, etc. They have high heat resisting qualities, their fusing point being over 2900° without shrinkage at 1750° F. (Even as high as 2000° F. the shrinkage is extremely small.) Crushing strength over 500 lb. to the sq. in. Used as an insulating course in boiler settings, furnaces, kilns, ovens or other structures where the conservation of heat and uniform temperature are desired.

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THE PERMUTIT COMPANY

440 Fourth Avenue NEW YORK N Y

BRANCH OFFICES

Albany, N. Y.....310 Journal Company Building
Boston, Mass.....10 Milk Street
Buffalo, N. Y.....304 Brisbane Building
Chattanooga, Tenn.....435 Vounteer Life Building
Chicago, Ill.....208 So. LaSalle Street
Kansas City, Mo.....401 Lathrop Building
Los Angeles, Cal.....404 Wright-Callender Building
Minneapolis, Minn.....1046 McKnight Building
Pittsburgh, Pa.....921 Union Arcade
Philadelphia, Pa.....311 Widener Building

AGENTS

St. Louis, Mo.—Reeves & Skinner Machinery Co., 2211 Olive Street.
Hamilton, Ontario, Canada—W. J. Westaway, Main & McNab Sts.
Montreal, Quebec, Canada—W. J. Westaway, 400 McGill Building.

Permutit Trade Mark Water Rectification Systems

AGENTS

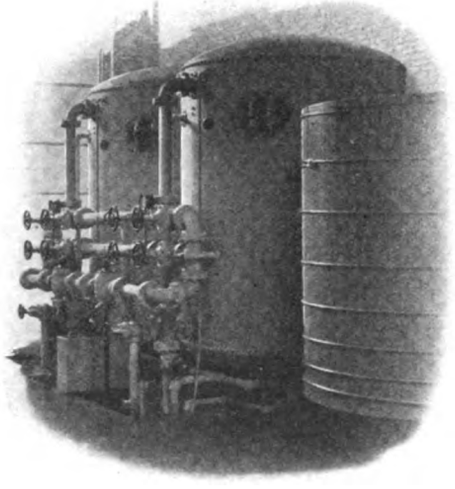
Vancouver, B. C., Canada—Engineering Corp., Ltd., Suite 903 Rogers Building.
Winnipeg, Manitoba, Canada—Stanley Brock, Ltd.
Calgary, Alberta, Canada—Stanley Brock, Ltd.

Products

A complete line of water rectification apparatus, including: Iron Removal Apparatus; Sulphur and Manganese Removal Apparatus; Water Softeners of Zeolite, Lime-Soda, and Heater Types; Filters and Filtration Equipment, Pressure and Gravity Types; Oil Removal Filters.

"Permutit" Zeolite Water Softeners

These are guaranteed to produce water of zero-hardness uniformly, regardless of the original hardness of the water or of variations in its hardness. No chemicals are used, and over-treatment or under-treatment is absolutely avoided. When the apparatus has delivered its guaranteed capacity of soft water, it is regenerated, i.e., restored to its original condition ready for further service, by treatment with a solution of common salt.



Arrangement of Two Permutit Zeolite Water Softeners for Continuous Twenty-four Hour Service

"Permutit" softened water for boiler feed absolutely prevents scale, keeps boilers clean all the time, eliminates boiler cleaning, reduces repair and replacement costs, saves labor, lowers fuel consumption, dispenses with reserve boilers, and gives a larger overload capacity.

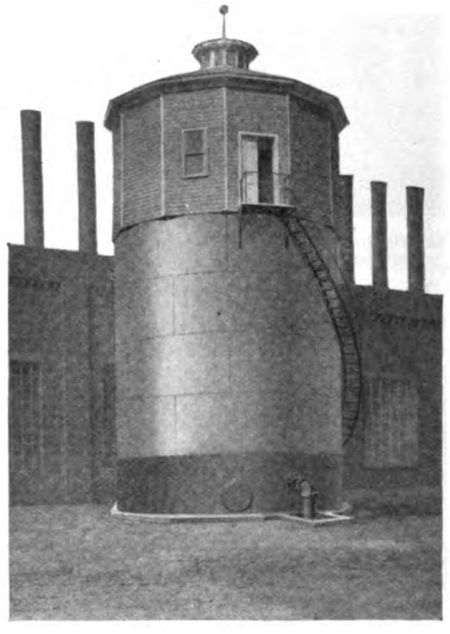
"Permutit" Iron Removal Apparatus

This may be either of pressure or gravity type, and may use either chemical or mechanical processes, as the conditions of each problem demand. Each equipment is specially designed to satisfy the local requirements in every particular.

The exceptional results secured are due: to extreme care in the preliminary investigation of the chemical and physical factors involved; second, to the specific design of the apparatus in accordance with the factors revealed by investigation. "Permutit" apparatus is simple and rugged in construction, easily operated and maintained, and absolutely certain in its results. It embodies the results of a wide and diversified experience, and has been developed to a point where iron removal is complete. The automatic delivery of water free from iron is guaranteed.

"Permutit" Lime-Soda Water Softeners

These are made in both continuous and intermittent types, and in any capacity desired. They embody every recent improvement in apparatus working under the principle of softening by precipitation, and produce the maximum results possible to be had by this system of water softening.



A Permutit Steel Continuous Lime-Soda Water Softener of the Top Mixing Top Operated Type, With Internal Quartz Clarifying Filters.

"Permutit" Sulphur and Manganese Removal Apparatus

This consists of a high-grade equipment designed for specific operating conditions with a view to securing assured results at minimum cost. Painstaking preliminary investigation is the basis of subsequent design that will properly care for every physical and chemical condition involved.

"Permutit" Filters and Filtration Equipment

This is supplied in both pressure and gravity types, with or without chemical feed, and in any capacity desired. A special feature is the minimizing of operating and maintenance costs.

Guarantees

With each "Permutit" installation goes a positive guarantee of results in accordance with the requirements of the specifications under which the order is placed.

Service

A competent and experienced staff of engineers and chemists is ready to study any problem in water rectification, and to recommend apparatus and processes. Inquiries are welcomed and will receive prompt attention.

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WM. B. SCAIFE & SONS COMPANY

FOUNDED 1802

PITTSBURGH, PA.

Executive Offices and Laboratory—Oakmont, Pa.

First Nat'l Bank Bldg., CHICAGO, ILL.

WATER WE-FU-GO AND SCAIFE PURIFICATION SYSTEMS SOFTENING & FILTRATION FOR BOILER FEED AND ALL INDUSTRIAL USES

26 Cortlandt Street, NEW YORK, N. Y.

Scaife Water Softening and Purifying Systems

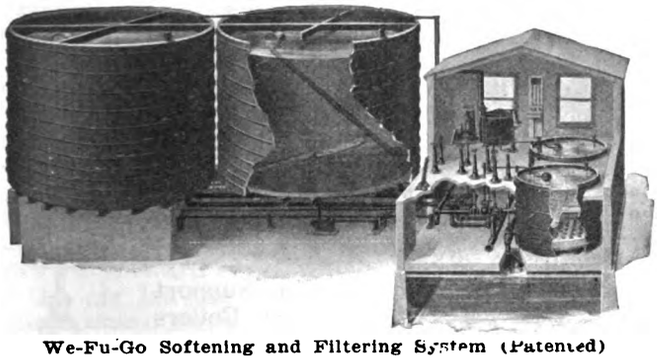
Our water softening and purifying systems are designed to meet the specific requirements in each case.

Scaife Filters and Filter Systems

Our Gravity Filter installations are designed with special reference to simple and accurate operating control. Our Pressure Filters include several types from which we can make selections for specific purposes.

The We-Fu-Go Softening and Filtering System

Measured quantities of water are treated in this system with accurately determined weights of reagents separately applied, so that the utmost accuracy in softening and purification is constantly maintained in water from any source by very simple tests that can be made by anyone of ordinary intelligence.

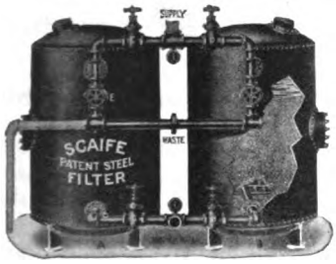


We-Fu-Go Softening and Filtering System (Patented)

This system neutralizes all acids, removes all iron, oil and grease. It softens to a definite standard and perfectly clarifies the water. The combined storage in the reaction-settling tanks and in the clear well of the system insures a constant supply of purified water for varying demands without affecting the softening and purifying process.

This system is free from complicated mechanisms or adjustments. It meets every requirement for the effective softening and clarification of water for domestic use, or for steam generation and any industrial purpose.

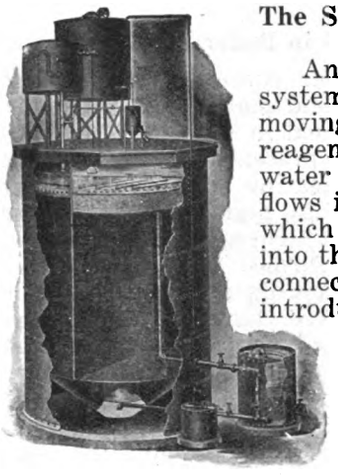
Scaife Pressure Flters



Scaife Pressure Filter (Patented)

These filters are designed to operate with water under pressure. They are usually built vertical in sizes up to 96 inches in diameter; but for large capacities they are built horizontal.

They are suitable for use where space is limited. They are adapted for the clarification of water for dwellings or offices, for swimming pools, and for many industrial uses.



Siphon Continuous Softening System (Patented)

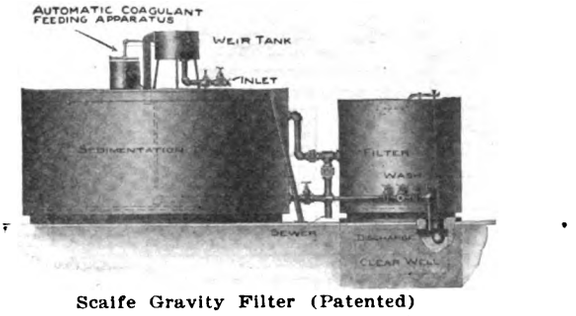
The Siphon Continuous Softening System

An automatic continuous system not dependent upon moving mechanical devices for reagent introduction. The water entering the system flows into a receiving tank to which is connected a siphon, into the long leg of which are connected small siphons which introduce the reagents in direct proportion to the discharge of the main siphon. This system can be arranged to operate from the ground or on top, and can be modified for special requirements.

Three other standard continuous softening systems are built and special systems are designed when required.

Scaife Gravity Filters

These filters are of the open tank type, built for any desired capacity. A complete Gravity Filter System includes an automatic coagulant feeding device, sedimentation tank, filter completely equipped, and in special cases for potable water, the necessary apparatus for sterilizing.



Scaife Gravity Filter (Patented)

The coagulant and other reagents are introduced automatically and proportionally by the inflowing water without the manipulation of valves. The starting and stopping of the flow of water also starts and stops treatment. These filter systems are practically foolproof and do not require expert supervision.

References

Atlas Portland Cement Co., New York, N. Y.
Bessemer Limestone & Cement Co., Youngstown, Ohio.
Crescent Portland Cement Co., Wampum, Pa.
Pittsburgh Plate Glass Co., Pittsburgh, Pa., 4 systems.
Marble Cliff Quarries Co., Columbus, Ohio.
Jones & Laughlin Steel Co., Pittsburgh, Pa., 4 systems.
U. S. Metals Refining Co., Carteret, N. J.
Pickands Mather & Co., Cleveland, Ohio, 4 systems.
American Encaustic Tiling Co., Zanesville, Ohio.
McKinney Steel Co., Cleveland, Ohio, 3 systems.
Youngstown Sheet & Tube Co., Youngstown, Ohio.
Republic Iron & Steel Co., Youngstown, Ohio.
Consolidation Coal Co., Fairmont, W. Va., 6 systems.
Weirton Steel Co., Weirton, W. Va., 2 systems.
W. J. Rainey, Uniontown, Pa., 4 systems.

Member of Associated Manufacturers of Water Purifying Equipment

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DE LAVAL STEAM TURBINE CO.

TRENTON, N. J.

Local Offices

Boston
New York
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Pittsburgh
Indianapolis

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Kansas City
Denver
Salt Lake City

Charlotte
Atlanta
Birmingham
New Orleans
Dallas

Seattle
San Francisco
Los Angeles
Montreal
Toronto
Vancouver

Products

The De Laval Steam Turbine Company builds Steam Turbines in capacities up to 15,000 H. P., and for all steam conditions; also De Laval Double-helical Gears for all speed ratios up to 25 to 1 in one step; De Laval Centrifugal Blowers and Compressors, single and multi-stage, for all volumes and for pressures up to 125 lbs. per sq. in.; and De Laval Centrifugal Pumps, horizontal and vertical, single and multi-stage, for all heads and capacities.

De Laval Centrifugal Pumps

De Laval Centrifugal Pumps for mine service are characterized by conservative speeds, high-class materials, construction on a limit-gage, interchangeable basis, guaranteed efficiency and capacity and a comprehensive system of testing, by which the fulfillment of these guarantees is demonstrated and the proper operation of the pump insured before it leaves our works.

De Laval Centrifugal Pumps require little or no foundations and do not produce vibration or pulsation in pipe lines, involve little cost for installation and are easily controlled from a distant point. Due to their low starting torque, they are easily arranged to be self-starting with either alternating or direct current motors. There are no valves or packings to be cut out by acidulous water nor by grit or other foreign matter.

De Laval Pumps are also directly connected to steam turbines. In larger sizes the De Laval Double-helical Speed-reducing Gear is employed, so that both turbine and pump can run at the speeds respectively most favorable to efficiency, thus giving the highest duties and the lowest cost for handling water, including capital, maintenance and operating charges.

Well Known Mining Companies Using De Laval Centrifugal Pumps

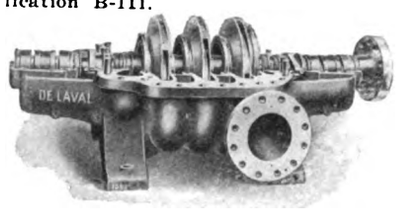
International Nickel Co.
Calumet and Hecla Co.
Raritan Copper Co.
Granby Mining, Smelting & Power Co.
Corrigan & McKinney Co.
Mining Corporation of Canada
Dominion Iron & Steel Co. of Canada
U. S. Steel Corp.
U. S. Metal Refining Co.
Aluminum Company of America
Erittania Mining & Smelting Co.
Illinois Zinc Co.
U. S. Aluminum Co.
Canadian Copper Co.
Oliver Iron and Mining Co.
New Jersey Zinc Co.
Northwestern Iron Co.
Newport Mining Co.
Cuyana Mills Iron Co.
American Smelting & Refining Co.
Garfield Smelting Co.
American Smelting Securities Co.
American Zinc Co.
Steptoe Valley Mining & Smelting Co.
Cobalt Reduction Co.
Michigan Copper Mining Co.

The **casing** is split horizontally, the suction and discharge connections and the bearing supports being included in the lower part. The casing cover can be lifted off without disturbing piping connections, giving access at once to all internal parts and permitting them to be lifted out after removing the bearing caps.

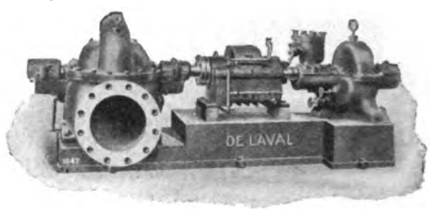
The design, workmanship and materials embodied in De Laval Pumps are such that the original **high efficiency** is maintained for a long period. The metals used for impellers, wearing rings, shaft sleeves, and similar parts subject to corrosion are the best obtainable. The De Laval **Labyrinth Wearing Ring** assists materially in maintaining the original efficiency, as it does not require small clearances in order to prevent excessive leakage and does not wear or cut away so rapidly as do flat wearing rings. Similarly, diffusion vanes are not used in De Laval Pumps, as they deteriorate rapidly, and we have developed other diffusion means of greater efficiency to which this objection does not apply.

The supplying of **finished repair parts,** made to accurate dimensions so that they can be put into a pump without requiring to be fitted, is part of the service which the De Laval Steam Turbine Co. gives the purchaser, due to its system of manufacturing parts to standard limit-gages. Each part is marked with a symbol number so that the identification and ordering of parts is easy and the De Laval stock room permits shipment from stock in most instances.

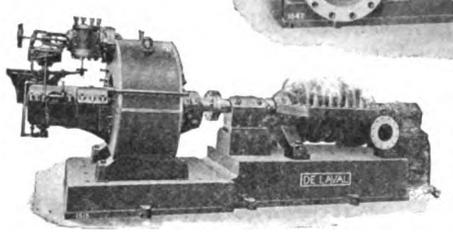
State your requirements of service so that our Engineering Department can specify the most suitable type of power, pumping or air compressing equipment. Ask for special publication B-111.



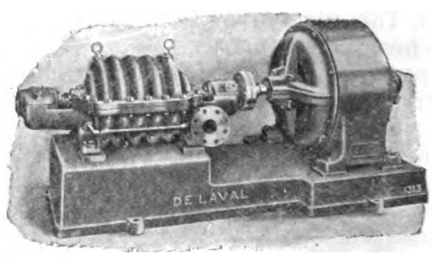
De Laval Multi-Stage Pump with casing cover removed.



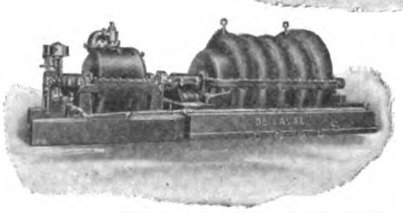
De Laval Centrifugal Circulating Pump driven by geared steam turbine, 6500 g.p.m., 25 feet head.



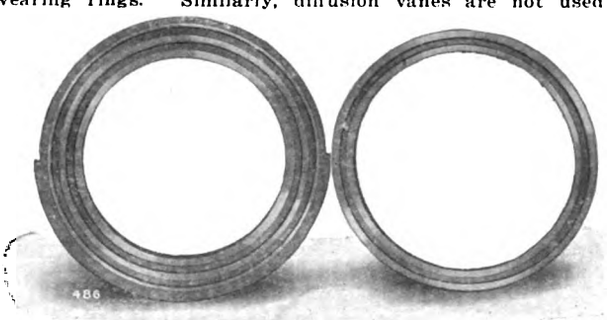
Turbine-Driven Boiler Feed Pump, 1200 g.p.m. 900 feet head at 1750 r.p.m.



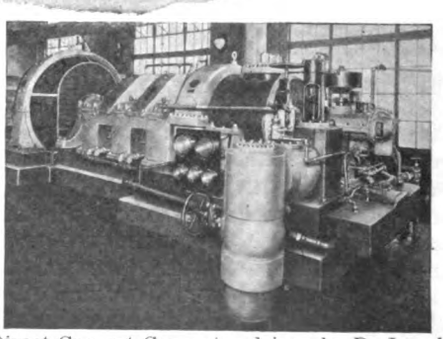
De Laval 4-inch Five-Stage Pump driven by induction motor, 500 g.p.m., 600 feet head, 1450 r.p.m.



De Laval Turbine-Driven Multi-Stage Compressor; 14,650 cu. ft. per min., from 10 inch water column vacuum to 8 lbs. per sq. in. gage.



Wearing Rings used to prevent leakage of water from the discharge to the suction chamber in De Laval Centrifugal Pump. The larger ring is held stationary in a recess formed in the pump casing and cover, while the smaller ring is fastened to the impeller.



Direct-Current Generator driven by De Laval Geared Steam Turbine, 1250 K. W.

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MOORE STEAM TURBINE CORPORATION

WELLSVILLE, N Y.

Steam Turbines Reduction Gears

Products

Condensing and Non-Condensing, Single and Multi-Stage Steam Turbines in sizes from 5 H. P. to 1500 H. P.

Double Helical Reduction Gears.

Turbo-Alternator Units.

D. C. Turbo-Generator Units.

Geared and Direct Connected Turbo-Blowers for forced draft, etc.

Turbo Pumps

Geared Belted Turbines.

Moore Steam Turbines

Have been developed to meet a demand for a highly efficient type of steam turbine.

They are made in the single and multi-stage types.

Points of Superiority

1. High efficiency—secured by the use of a velocity wheel, followed by single pressure stages.

2. Low Steam Velocities—secured by multi-staging.

3. Accessibility—secured by use of a horizontally split casing in all sizes.

4. Emergency Governor—furnished on all turbines.

5. An Improved Type of Carbon Packing having the carbon rings encased in brass cases to prevent breakage.

6. Moderate Speeds.

7. An improved method of fixing the diaphragms in the casing.

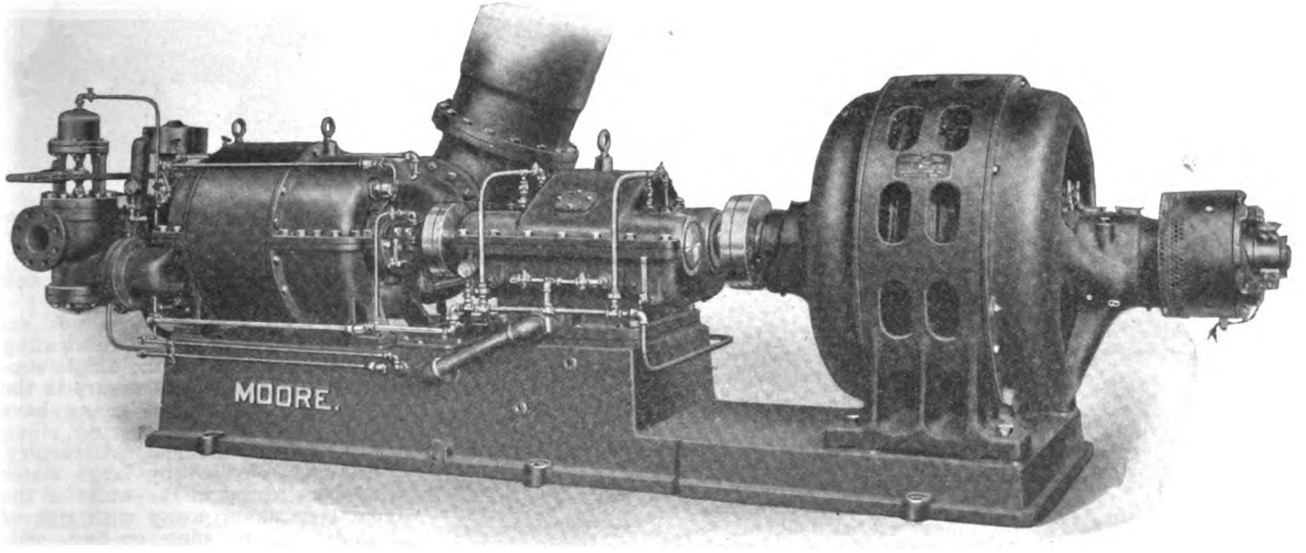
8. Buckets made from cold drawn stock, having smooth working surfaces and perfect alignment in the wheel.

Double Helical Reduction Gears

Moore Gears are cut on Gear Hobbing Machines of the latest and most approved type. These machines have been specially designed to produce the highly accurate workmanship required to secure a satisfactory reduction gear for operation at high speeds such as are encountered in turbine work.

The Gears are of the double helical or herringbone type. A pressure angle of 20 degrees, and a helix angle of about 35 degrees is used.

Our processes of manufacture and inspection of these gears are such as are necessary for the production of a strictly high-grade piece of mechanical apparatus.



Typical Moore Geared Type Turbo-Alternator Unit with Direct Connected Exciter. Turbine is Equipped with Oil Relay and Emergency Governors and Forced Feed Lubrication to Turbine and Gear Bearings.

Our engineers are always prepared to go into your requirements in detail and give their advice and recommendations, in your interests, without placing you under any obligations whatever.

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THE TERRY STEAM TURBINE CO.

Main Office and Works

HARTFORD, CONN.

BRANCH OFFICES AND AGENCIES IN PRINCIPAL CITIES

Products

Terry Steam Turbines, condensing and non-condensing; Turbo-Generator Sets; Turbo-Pump Sets and Turbo-Blowers.

Terry Turbines

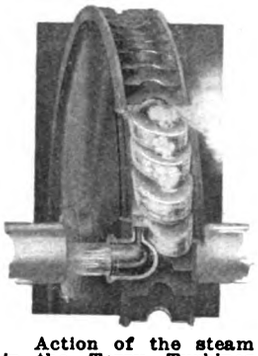
Are furnished separately or with driven apparatus in complete units with or without reduction gears. Turbine sets include all kinds of centrifugal pumps for every service, turbo-generators, alternating or direct current, for lighting or power purposes; induced draft fans, exhausters, turbo-compressors and forced draft fans. Over 8,000 Terry Turbines in operation.

Capacities

Horizontal Terry turbines are built in sizes from 1 to 1,500 H. P.; vertical types up to 600 H. P.

Description

The aim in developing the Terry turbine has been toward perfection in design rather than minimum first cost. High operating efficiency, long life and low upkeep cost have been considered of more value than low price. The advisability of this policy is proved by the extensive use of Terry turbines in the exacting services of large central stations and ships of the U. S. Navy. The outstanding feature which makes the Terry so simple and reliable is its principle of operation. Steam is distributed by a steam chest or steam ring to a series of nozzles. In these nozzles the steam is expanded from approximately boiler pressure to exhaust pressure. Issuing from the nozzle at high velocity it strikes the side of the steam bucket in which its direction is reversed 180°. As the initial impact absorbs only a part of the total energy, the jet of steam passes into a reversing chamber which returns it to the wheel bucket. This action is repeated several times until all of the available energy is utilized.



Action of the steam in the Terry Turbines whereby the steam is returned to the wheel again and again until all the available energy is utilized.

Tubro-Generator Sets

Built in sizes up to 750 K. W., condensing or non-condensing, geared or direct connected, direct or alternating current. Non-condensing units are used extensively in plants requiring exhaust steam for commercial uses or heating; also used in the smaller sizes as auxiliaries or night lighting sets. Condensing units are divided into three classes: Straight high pressure, mixed pressure and bleeder. The mixed pressure units are adaptable to plants having varying amounts of exhaust steam available, the bleeder unit being used in plants where exhaust steam is required but not enough to warrant the use of a straight non-condensing turbine.

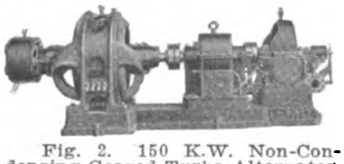


Fig. 2. 150 K.W. Non-Condensing Geared Turbo-Alternator.

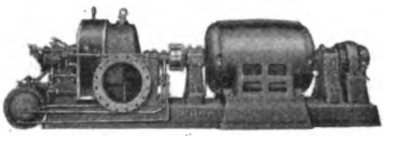
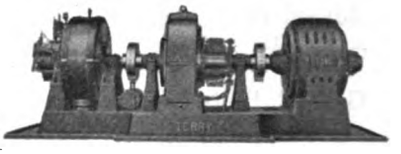


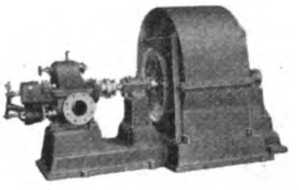
Fig. 3. 300 K.W. Straight High Pressure Condensing Alternator.

Duplex Exciters

These sets consist of an exciter-generator driven from one end by a motor and from the other end by a specially governed Terry turbine. The exciter ordinarily is driven by the motor. Should the motor fail the turbine will automatically take hold without causing appreciable fluctuation in the exciter voltage. These sets have met with marked success because of their inherent reliability.



Duplex Exciter Unit. Used extensively because of reliability and adaptability to automatic heat balance.



Induced Draft Fan. Small space and light foundation make it readily adaptable to plant conditions.

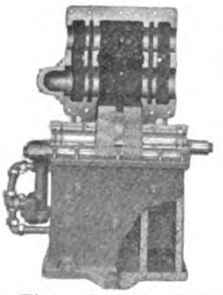
Forced and Induced Draft Sets

Fan units are usually installed in objectionable locations, often requiring very light foundations in places where they are subject to excessive heat and dirt. The Terry turbine with its freedom from vibration, its ability to operate over long periods under adverse conditions without attention is particularly adaptable to this service.

Turbo-Pump Sets

Are adapted to all classes of service including boiler feed, condenser circulating, hotwell, dredging, fire protection service and general service.

Geared Condenser Circulating Pump. We invite inquiries on complete pumping units for all classes of service.



The Terry Gear. Horizontally split throughout, giving complete accessibility.

Reduction Gears

The teeth are cut by the most accurate methods and the lubricating system is unusual in the ample supply of cool oil under pressure to the bearings. All Terry gears have forced feed lubrication, ring oiling not having been found satisfactory. Cooling is effected by large water chambers, cored in the walls of the gear case, doing away with risk of leakage where pipe cooling coils are used.

Experience gained in over eight thousand installations insures the purchaser against faulty workmanship, material or design.

Write or phone the nearest district office.

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Worthington Pump and Machinery Corporation

Executive Offices
115 Broadway, NEW YORK

For List of Works and Offices, See Page 493

Condensers and Auxiliaries, Feed Water Heaters

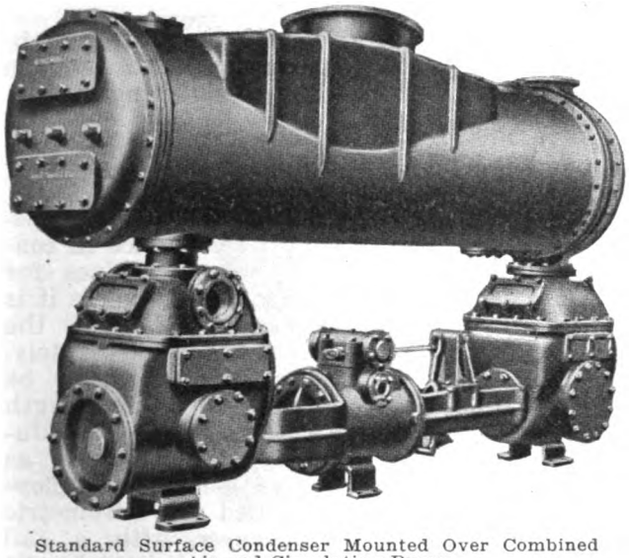
Products

Surface Condensers; Jet Condensers; Barometric Condensers; Circulating Pumps; Air Pumps; Vacuum Pumps; Ejectors; Boiler Feed Pumps; Pressure Pumps; Centrifugal Pumps; General Service Pumps; Feed Water Heaters and Purifiers. For other products see Pages 166, 167, 176, 463, 493, 626 and 741.

Worthington Standard Surface Condensers

Cylindrical in form and fitted usually with untinned brass tubes passing through stuffing boxes, located in brass or muntz metal tube heads.

Tube heads are carefully drilled and tapped, and receive threaded brass ferrules, which are provided with lip on the inside to prevent the tube from creeping, but designed to allow freedom for expansion and contraction, and for quick removal or repacking of any tube in case of leakage.



Standard Surface Condenser Mounted Over Combined Air and Circulating Pump

Stuffing boxes are packed with lacing fibre ferrules or wicking, as preferred.

The tubes may be expanded into one or both of the tube heads where required.

The steam enters the condenser shell, passing over the outside of the tubes through which cooling water is forced at suitable velocity; a deflecting plate is located in the shell near the exhaust opening to assist in distributing the steam over the entire tube surface, and added steam space is also provided at the top of the shell above the tube surface to assist in this distribution. The cooling water passes through the tubes two or three times, entering at the bottom and leaving at the top of the condenser, thus forming a counter-current condenser as the exhaust enters the top of the condenser and the condensed steam is removed from the bottom of the shell. A single vacuum pump of the so-called wet type extracts both the steam and non-condensable vapors from the shell at this point.

The circulating pump may be either direct-acting or centrifugal.

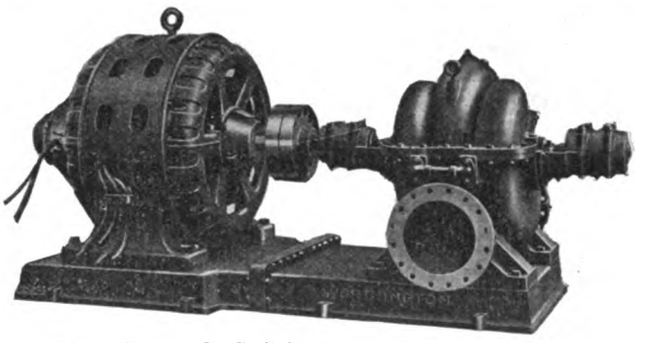
Standard Condensers are built to withstand a hydraulic test pressure of 25 pounds per square inch in the water space. Condenser shell, water boxes, bonnets, round and flat heads are made of close-grained cast iron, suitably ribbed where necessary to provide a wide margin of safety for the pressures encountered. Ample provision is made for inspection through manholes and steam hole plates.

Auxiliaries

The Worthington line of auxiliaries for Standard Surface Condensers is broad and complete.

Where centrifugal pumps are desired to circulate the water to surface condensers, the Worthington line offers pumps of many designs. The split casing volute pump meets most requirements for quick accessibility, high speed, simple design and low maintenance cost. Where unusual nozzle positions must be met on account of location or special drives must be utilized, special types of centrifugal pumps can be furnished, either vertical or horizontal.

Vacuum Pumps may be furnished to handle both the air and non-condensable vapors and may be of various designs, vertical or horizontal.



Motor-Driven B. S. Split Casing Centrifugal Pump

Centrifugal Circulating Pumps are recommended to circulate water for high vacuum surface condensers. They may be arranged for steam turbine or motor drive.

It is possible to vary the design of the impellers to permit the delivery of fixed quantity of water at varying pressures, or of varying quantities at a fixed pressure, or to combine the quantity, pressure and speed within a wide range. The style most favored for ordinary surface condenser work is the split casing type.

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Vertical Shaft Pumps are used where the conditions are such that a horizontal pump cannot be placed within suction distance of the source of supply, such as in a deep well, or along the banks of a stream, where the difference in level between high and low water amounts to 20 or 30 feet.

Hotwell Pumps are made in solid and split casing types. The solid casing permits the withdrawal of the impellers and shaft from the end without dismantling the pump; the split casing permits inspection and removal of rotors without dismantling the pump. These pumps can be furnished in either vertical or horizontal types.

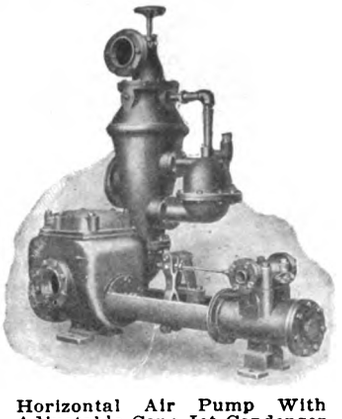
Dry Vacuum Pumps are built in the two-stage single cylinder type. This is distinctly a dry vacuum pump, no water whatever being used inside the cylinders. This pump permits the selection of a smaller pump than the earlier types of flywheel pumps.

All of these pumps have the Laidlaw FEATHER Valve, (Reg. U. S. Pat. Off.) a description of which will be found on Page 160 in the Power Plant Section of this book.

Worthington Hydraulic Vacuum Pump removes the air and non-condensable vapors from the condenser by means of hurling, at a high velocity, jets of water approximately rectangular in cross section from a revolving wheel, the water jets rushing through the discharge cone and diffuser in the form of a helix, enclosing the vapors which enter around the rotary transforming wheel between the jets or pistons of water. The jets or pistons gradually and effectively compress the air and condense any steam vapors on the way to the vacuum pump discharge.

The main advantages of this pump are: Highest vacuum **obtained;** highest vacuum **maintained,** owing to its capacity for handling excessive air leakage and practical elimination of wearing parts; great elasticity and capacity; reduction of power and possible convenience in pumping arrangement.

Steam Ejectors are used where space is limited and weight is a controlling factor. Their reduced cost also requires their consideration for other installations.



Horizontal Air Pump With Adjustable Cone Jet Condenser

Worthington Jet Condensers

The illustration shows a Worthington Horizontal Wet Vacuum Pump with an adjustable spray cone condenser.

The adjustable cone is used for the purpose of regulating the thickness of the water spray and the amount of injection water supplied to the condenser. It is also a convenient means of flushing out the condenser in case it becomes clogged with grass or other obstacles that may possibly enter with the injection water.

The cone adjustment for the largest sizes is arranged with the hand wheel on the side of the condenser body instead of on the top, as shown in the illustration, and the upper elbow is omitted altogether. The exhaust steam enters at the top and is condensed immediately by the injection spray. It then falls to the bottom of the condenser and is removed by the vacuum pump. An automatic vacuum breaker safety attachment is placed on this type of condenser to prevent the water from rising any higher in the condenser than the proper level. If, by accident, the pump should stop while the main engine or turbine is in operation, the water will rise in the condenser and when it reaches a certain level will raise a float, which in turn raises the relief valve from its seat, thus admitting air into the condenser and destroying the vacuum. When the pump is started again, the float drops, permitting the valve to close and the work of condensation is promptly resumed. In this way, the possibility of flooding the main engine or turbine is avoided.

For service with steam turbines and for high vacuum work, a wet vacuum pump is generally fitted with a specially designed type of counter-current condenser and the air and water handled separately.

Worthington Counter Current Barometric Condenser

A dry vacuum pump is used to extract the air after being cooled and the condensed steam and injection water are pumped out by means of the wet vacuum pump. In this way the highest possible vacuum is produced and can be maintained with maximum degree of economy.

Many combinations of Worthington Jet Condensers can be made with standard direct-acting vacuum pumps.

Worthington Barometric Jet Condensers

This condenser has been especially designed for service in connection with steam turbines for high vacuum generally where it is necessary to handle the air and water separately. The condenser can be used with a short length of tail pipe as a centrifugal jet condenser, or as more generally employed, used as a barometric condenser with a tail pipe approximately 34 feet long. In this case, a vacuum pump is used to extract the air and non-condensable vapors and a circulating pump to deliver condensing water to the condenser, where the supply level is more than 20 feet below the level of the water inlet into the condensers.

Worthington Feed Water Heaters, Stilwell Type

A combined feed water heater, feed water purifier and water softener, made in vertical and horizontal types, the latter being shown in the illustration on the next page.

The shell is made of cast iron, in sections, depending on the size of the heater. The heads are bolted to the shell and contain the hinged doors for inspection, cleaning and removal of pans.

The water enters the top of the heater and is discharged into the overflow box, flowing over its

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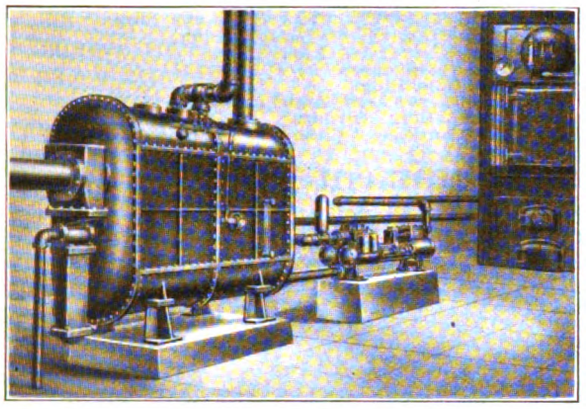
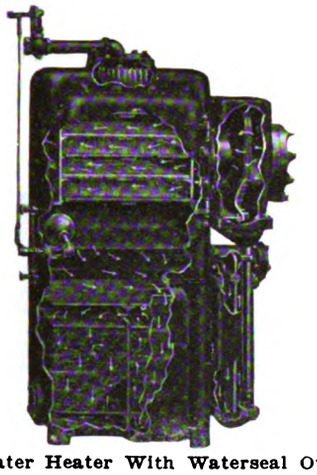
sides in a thin, distended sheet and passing down through the incoming current of exhaust steam to the top pan, and thence through the entire pan system to the heating chamber. From the heating chamber the water passes to the settling chamber, where the heavier solids are precipitated, and from there to the filter where the final purification takes place. The water then passes to the pure water chamber and is ready for use.



Horizontal Feed Water Heater, Sectional Type

An oil separator is attached to all heaters to collect the oil carried by the water.

The horizontal type of heater is built in sizes up to 20,000 H. P.



Feed Water Heater With Waterseal Overflow

Worthington Vertical Feed Water Heater, Stilwell Type

The Vertical heater is similar in operation to the horizontal type, except that the shell is rectangular in form, as shown in the illustration above.

The pans overflow at the edges in both types, there being no perforations to clog up and the pans can be easily removed for cleaning purposes.

The water supply in both types is automaticaly controlled and an overflow arrangement is provided.

Filter material is easily renewed, it consisting of hay, excelsior, coke or other suitable material.

The Vertical heater is built in nine sizes from 50 H. P. up to and including 1,000 H. P.

General Service and Boiler Feed Pumps

Worthington General Service and Boiler Feed Pumps embrace a wide variety of sizes and types, for pressures up to 150 lbs. These pumps can be made for handling gritty water, or for any standard service. Their construction is of the best material and workmanship.

For high pressure service the Worthington Pot Valve Pressure Boiler Feed Pump is recommended. Water ends are safe for 300 pounds; plungers are outside end packed; stuffing boxes easily accessible; water valves are of bronze composition.

This type of pump is especially desirable for hot water.

Made in capacities from 250 to 9,700 boiler H. P.

Where space is an item, however, the use of the Center-Packed Pump of this line, which is built in capacities from 4,000 up to and including 9,700 boiler H. P., is recommended.

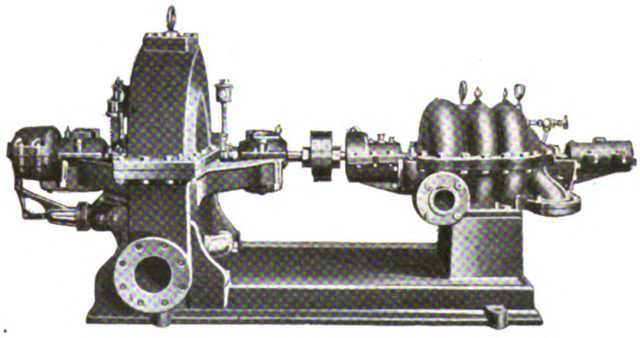
Where economy of operation is the first consideration, or where the size of the plant makes it desirable, compound steam cylinders may be employed. This type of pump uses about 30% less steam than the simple type when performing the same work.

This pump is built either end-packed or center-packed in sizes from 4,000 to 9,700 boiler H. P., and when required, the smaller pumps described above may be equipped with compound steam ends.

Centrifugal Boiler Feed Pumps

The illustration shows a Three-Stage Boiler Feed Pump with steam turbine drive, which is the most satisfactory method of operating this type of pump. The principal advantages of this method of driving is an uninterrupted and steady discharge, thus eliminating all shock on the pipe system. Air chambers and relief valves are not necessary, as the pressure will not build up to a dangerous point, even though the discharge valve is entirely closed.

In plants where the load is subjected to considerable fluctuation, it is recommended that the work be divided between two or more units rather than attempt to handle the full capacity with one pump.



Three-Stage Boiler Feed Pump, Steam Turbine Drive

Worthington makes various types of Volute pumps with double suction impellers. Type O. S. built in different capacities of single-stage construction to handle water up to 100-ft. heads; Type B. S. handles water up to 200-ft. heads; Type S. D. handles water up to 360-ft. heads and is built in two stages.

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Allis-Chalmers Manufacturing Company

MILWAUKEE, WISCONSIN

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Power and Electrical Equipment

Products

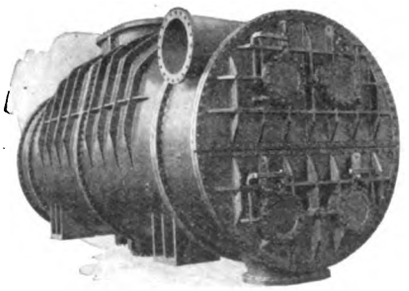
Power Equipment—Steam Turbines, Steam Engines, Condensers, Gas Engines, Oil Engines, Hydraulic Turbines, Electric Power Units complete with any type of prime mover.

Electrical Equipment—Motors for all purposes, Alternating Current and Direct Current Generators, Motor Generator Sets, Transformers, Synchronous Converters, Frequency Changers, Balancers, Boosters, Synchronous Condensers, Switchboards.

Industrial Machinery—Mining and Metallurgical Machinery; for Ore Dressing and Milling Equipment, see page 620; for Smelting and Refining Equipment, see page 740; for Crushing and Grinding Machinery, see page 491; for Cement Making Machinery, see page 491; for Centrifugal Pumps and Pumping Units, see page 454; for High Pressure Mine Pumps, see page 454; for Pumping Engines, see page 454; for Steam and Electric Hoists, see page 397; for Portable and Stationary Air Compressors, see page 169; Power Transmission Machinery; Flour Mill Machinery; Saw Mill Machinery; Timber Treating and Preserving Machinery; Farm Tractors; Special Road Tractors; Heavy Forgings, etc.

Condensers

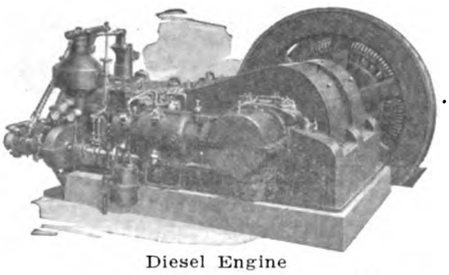
These are built in the surface, jet and barometric types and include a complete line of condenser auxiliaries.



Surface Condenser

Diesel Engines

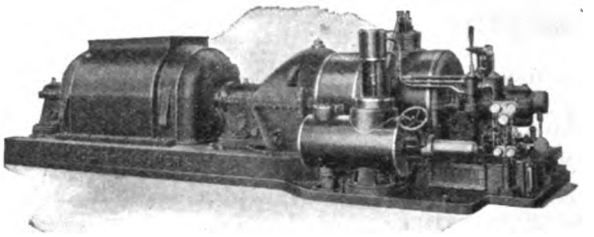
The Allis-Chalmers oil engine combines all the economical advantages of the Diesel system, together with special constructive features essential for reliability in service. The engine is of the four-stroke cycle horizontal type with an open fuel nozzle and a low pressure starting system.



Diesel Engine

Steam Turbines

Allis-Chalmers steam turbine and alternator units, condensing, non-condensing, mixed pressure and low pressure types, built in sizes from 200 K. W. up.



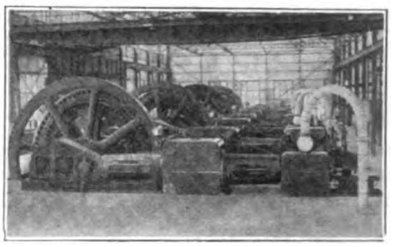
4000 K. W. 3600 R. P. M. Turbo-Alternator Unit

Allis-Chalmers steam turbines are of the horizontal reaction type, highly efficient, simple in design, accessible for inspection and built for continuous service.

Corliss Engines

The Corliss Engine is the most reliable and efficient of reciprocating engines.

Our full line of engines and 50 years' experience enable us to furnish an engine best suited to meet all conditions.

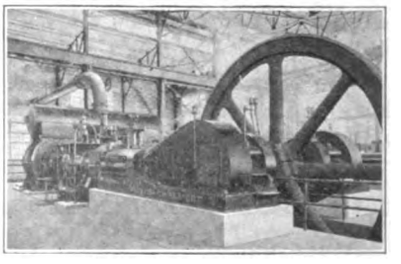


Four 2200 Kv-a. Engine Driven Alternator Units. Ray Consolidated Copper Co.

Blowing Engines

Allis-Chalmers Blowing Engines are built in all sizes, in vertical and horizontal types, for steam, gas, oil or electric motor drive, for any pressures and all purposes.

The special features of design are reduction of clearance to a minimum, large inlet and outlet area to reduce friction losses and beating and insuring complete filling of cylinders at all speeds, short and direct inlet parts and accessibility of parts.



Steam Driven Compressor for Copper Converter

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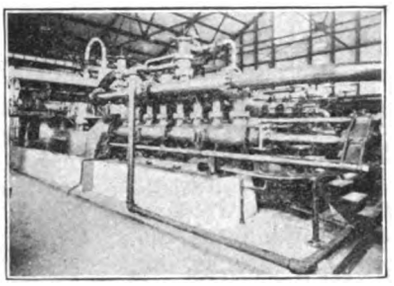
High Pressure Mine Pumps

Duplex, double-acting, outside end packed types either steam or electrically driven through herring-bone reduction gears or direct mounted. Built for any capacity up to 2,000 g.p.m. and heads up to 2,500 feet.

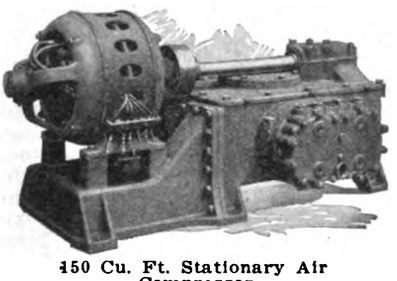


High Pressure Mine Pump

Whatever your pumping conditions, we invite your inquiries, and our engineers with years of practical experience will help solve your pumping problems.

Air Compressors

These are built in the stationary and portable types and for motor or belt drive. Sizes suitable for mining service range from 11 to 150 cu. ft. capacity.



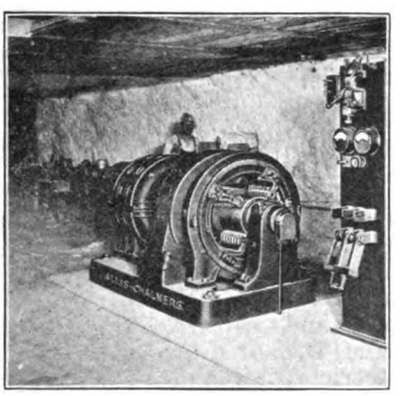
450 Cu. Ft. Stationary Air Compressor

Alternating and Direct Current Generators

Allis-Chalmers generators are built in the belted type or direct connected type for engine, steam turbine, or waterwheel drive, both horizontal and vertical for the latter drive. Ratings and speeds are adapted to the various types of prime movers. Complete units can be furnished with any type of prime mover, thereby giving purchaser undivided responsibility.

Motor Generator Sets

Motor generator sets are built in all standard sizes for mine service. The special moisture-proof form wound coils, the correct and liberal design of all parts, assures large momentary overload capacity. The method of supporting the brush rigging, etc., affords ready access for inspection and cleaning.

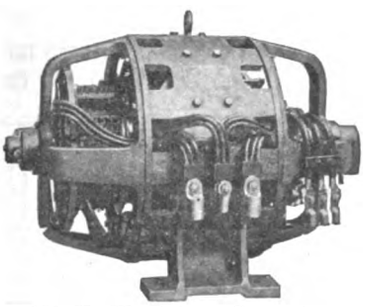


150 K.W. 1170 R.P.M. Induction Motor-Generator Set for Battery Charging

Combinations are built of self-starting synchronous motors, induction motors, direct current, two or three wire generators, etc.

Synchronous or Rotary Converters

Standard synchronous converters, or "rotaries," for industrial or mining service deliver 250 to 275 volts direct current, when operating from the alternating current supply system.

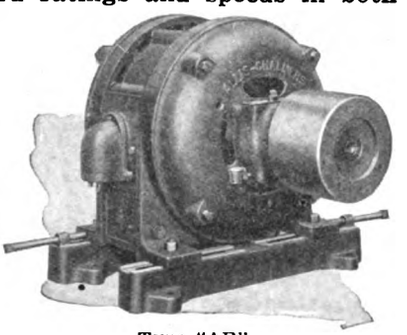


150 K. W. Rotary Converter

They are built for ratings of 100 K.W. and larger, in the commercial pole type, and for 60 cycle and 25 cycle systems.

Polyphase Induction Motors

Made in standard ratings and speeds in both squirrel cage and slip ring types for belt drive or direct connection. They are of very rugged construction and therefore adapted to severe service conditions. Shafts are large and rigid while the bearings are liberal in size. Moistureproof coils are used.

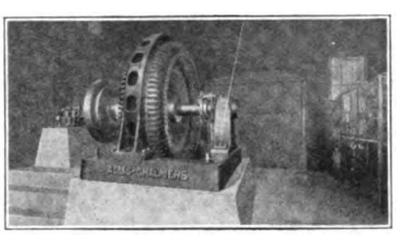


Type "AR" Squirrel Cage Induction Motor

Slip ring motors are for use where the starting conditions are severe and starting current must be kept low, and for varying speed requirements.

Synchronous Motors and Condensers

Synchronous motors are especially suited for driving generators, large air compressors, pumps, line shafts and other constant speed apparatus where the starting conditions are not severe. The corrective effect which they exert on the power system makes them particularly desirable for alternating systems where the power factor is low. Built for ratings of 50 H. P. and larger.



350 H. P. 212 R. P. M. Synchronous Motor Driving Mine Fan

Direct Current Motors

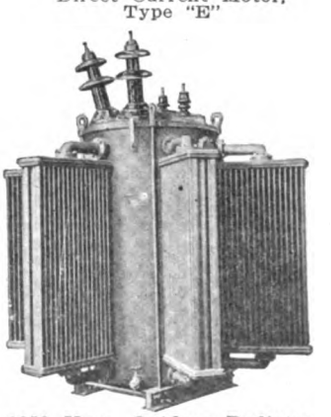
Type "E" Motors are made in ratings and speeds corresponding to those of constant speed induction motors, as well as adjustable speed ratings, in capacities up to 200 H. P. They are of rugged construction with commutating poles insuring sparkless commutation, dustproof bearings, thorough ventilation, windings treated to resist oil and moisture. Larger ratings built in the pedestal bearing type.

Direct Current Motor, Type "E"

Transformers

These transformers are designed for power and lighting service. They are built in all commercial sizes for lighting and power transmission, and for use in connection with Rotary Converters.

They are furnished in self-cooled, water cooled, and air cooled types, wound for all voltages and frequencies, embodied in mining service.



1250 Kv-a. Outdoor Radiator Type Power Transformer

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INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Power Plant and Drilling Equipment

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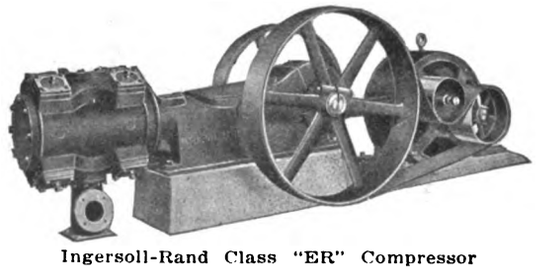
To insure correspondence against avoidable delay, all communication should be addressed to the place nearest the writer.

Products

Air, Gas and Ammonia Compressors; Air Receivers; Aftercoolers; Reheaters; Turbo Blowers and Compressors; Oil, Gas and Steam Engines; Marine Engines; Condensers; Air Pumps for Condensers; Vacuum Pumps; Steam Jet Pumps. For other products see pages 298, 299, 300, 458 and 459.



Ingersoll-Rand Class "ER" Compressor

Class "ER-1" Compressors

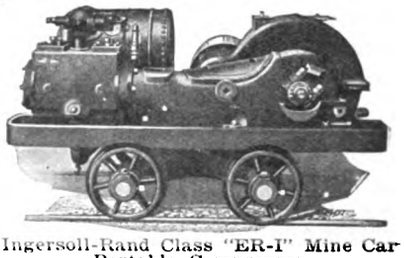
Single-stage, double-acting, straight-line compressors of enclosed construction arranged for belt drive. Running parts and main bearings are lubricated by an automatic flood system. The inlet and discharge valves are of the Ingersoll-Rand Plate Type. Reliable regulators, automatically loading and unloading the compressor can be supplied for all sizes. These compressors can also be furnished with the short belt drive and suitable motor and control to suit any electric current condition, or with tight and loose pulleys for shaft drive. Bulletin 3330.

Piston displac., cu. ft. per min.	Pressure, lbs. per sq. in.	Speed, r. p. m.	B. h. p. inc. belt loss	Floor space
28	100-150	500	4 -4.3	4′ 0″x1′6″
44	20-100	500	3.8-6.5	4′ 2″x1′6″
44	100-150	400	6.5-7	5′ 2″x1′9½″
64	45-100	400	7.3-9	5′ 4″x1′9½″
67	100-140	350	10-10	6′ 6″x1′11″
92	45-100	350	11-13	6′ 8″x1′11″
113	100-130	250	19-21	8′ 0″x2′6¼″
145	65-100	250	21-24	8′ 1″x2′6¼″
223	100-120	250	39-42	9′ 9″x3′2¼″
324	50-100	250	43-57	9′ 5″x3′2¼″
340	100-115	220	54-56	11′ 0″x4′1¾″
464	40-100	220	53-74	11′ 3″x4′1¾″

Data on standard machines for low pressures on request.

Class "ER-1" Mine Car Compressors

These are self-contained power plants consisting of an "ER" Compressor with automatic unloading device; air receiver with pressure gage, safety valve, drain cock and service valve; D.C. or A.C. electric motor and control; gear drive; all mounted on a steel frame with wheels and axles. It is fully equipped and needs only to be connected to a source of electric power. Can be furnished for any com-



Ingersoll-Rand Class "ER-1" Mine Car Portable Compressor

Piston Displac., cu. ft. per min.	Air Pressure Designed For	Brake Horse Power	Overall Dimensions Feet and Inches		
			Length	Width	Height over Rails
78	90-100	12-12.5	7′	4′-0″	3′-8″
145	90-100	23-24	8′-3″	4′-8″	4′-4″
209	90-100	35-37	10′	5′-6″	4′-6″
304	90-100	51-53	10′	5′-6″	4′-6″

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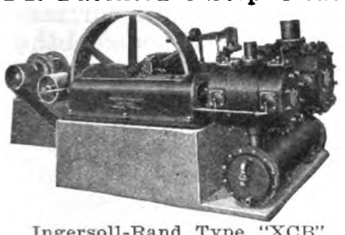
mercial track gauge. The compressor is the same as the Class "ER-1" already described except that all sizes have the Hopper type of air cylinder water jacket. Bulletin 3016.

Type "XCB" Compressors

Duplex construction, single or two-stage, with I-R Patented 5-Step Clearance Control automatically unloading or loading compressor in five steps, viz.: full, three-quarter, one-half, one-quarter and no load. These compressors are dust - proof, enclosed construction, automatic flood lubrication for moving parts and force feed lubrication for air cylinders. The air valves are of the Ingersoll-Rand Plate Type. Can also be furnished with the short belt drive and suitable motor and control to suit any electric current conditions. Bulletin 3042.



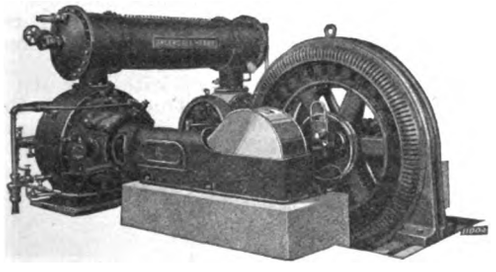
Ingersoll-Rand Type "XCB" Compressor

Piston Displac., Cu. Ft. of Free Air Per Minute	Brake Horse-Power Required at Belt Wheel of Compressor — Air Pressure		Over-All Dimensions Feet and Inches	
	80 lbs.	110 lbs.	Length	Width
610	96	109	10-7	6-5
877	134	153	11-9	7-8
1244	191	218	13-0	8-8
1505	232	263	13-3	10-4

Data on standard machines for altitudes on request.

Class "PRE" Compressors

Duplex construction, single or two-stage, direct-connected motor driven, the rotor of the motor being securely pressed and keyed on the compressor shaft, dust-proof, enclosed construction, automatic lubrication. Ingersoll-Rand Plate Inlet and Discharge Valves. This compressor has I-R Patented 5-Step Clearance Control, automatically unloading or loading the compressor in five steps, viz.: full, three-quarter, one-half, one-quarter and no load. Bulletin 3126.



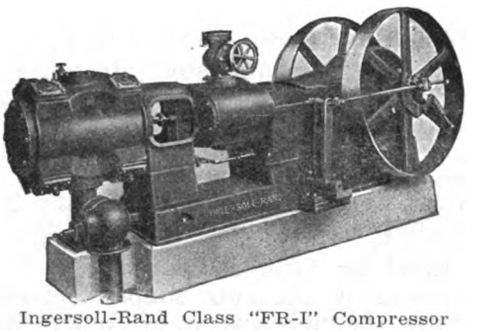
Ingersoll-Rand Class "PRE" Compressor

Piston displace., cu. ft. per min.	Motor b. h. p. at air pressures given		Floor space
	90 lbs.	100 lbs.	
627	100	105	10'0"x10'3"
1052	169	177	11'1"x12'1"
1302	201	210	11'9"x11'9"
1574	251	264	14'3"x12'6"
2033	309	324	16'0"x14'4"
2874	455	478	18'0"x16'0"
3864	635	666	18'4"x19'0"
5011	752	787	25'0"x19'0"
5967	972	1020	29'3"x20'0"
7440	1120	1179	30'9"x26'0"

Data on standard machines for altitudes on request.

Class "FR-1" Compressors

Single-stage, double-acting, straight-line, steam driven compressors. Running parts and main bearings are lubricated by an automatic flood system. The inlet and discharge valves are of the Ingersoll-Rand Plate Type. The air cylinder is direct-connected to steam engine having balanced piston valve with automatic cut-off fly wheel control governor, making it possible to operate with high pressures and superheated steam, as well as with moderate pressures and saturated steam. Bulletin 3131.



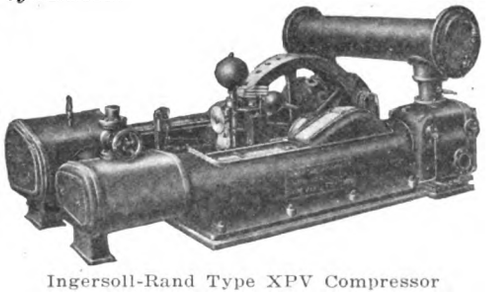
Ingersoll-Rand Class "FR-I" Compressor

Piston Displac., Cu. Ft. per Minute	Air Pressure Designed For	I.H.P. in Steam Cylinder	R.P.M.	Diam. Fly Wheels Ft. In.	Overall Dimensions Feet and Inches — Length	Width	Height from Floor
67	100-140	10-10	350	2-5	8-2	2-2	3-6½
92	45-100	11-13	350	2-5	8-3	2-2	3-6½
136	100-130	23-25	300	3-5	10-3	2-8	4-0½
173	65-100	25-29	300	3-5	10-4	2-8	4-0½
245	100-120	43-46	275	4-2	12-1	3-4	4-9
355	50-100	47-63	275	4-2	11-11	3-4	4-9
386	100-115	62-64	250	5-2	13-9	4-2	5-10
528	45-100	64-84	250	5-2	13-11	4-2	5-10

Data on standard machines for low pressures on request.

Types "X" and "XPV" Compressors

Duplex construction, single or two-stage with simple or compound steam cylinders, dust-proof enclosed construction, automatic lubrication for all moving parts and force-feed lubrication for air and steam cylinders.



Ingersoll-Rand Type XPV Compressor

The Type "X" has D steam valves on small sizes and Meyer Adjustable Cut-Off type on larger units. The type "XPV" has automatic cut-off governor and balanced piston steam valve and is suitable for high steam pressures and superheat. Bulletin 3311 covers Type "X", and 3133, Type "XPV".

DATA ON "XPV" COMPRESSORS

Piston Displacement. Cu. Ft. Free Air Per Minute	I.H.P. in Steam Cylinders — 80 lbs.	90 lbs.	100 lbs.	110 lbs.	Overall Dimens'ns Feet and Inches — Length	Width
648	102	108	114	120	12-0	7-8
940	148	157	165	174	13-6	8-9
1260	200	212	223	235	14-0	9-2
1531	242	256	270	284	17-4	10-3
1955	306	326	344	360	17-10	11-0

Data on standard machines for altitudes on request.

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Class "ORC" Compressors

The Class "ORC" Compressors are duplex steam driven units with single or two-stage air cylinders and single or cross compound Corliss valve steam cylinders. Capacities from 2550 to 8000 cu. ft. per minute, pressures to 115 lbs. per sq. in. Bulletin 3129.

Ingersoll-Rand Air Receivers

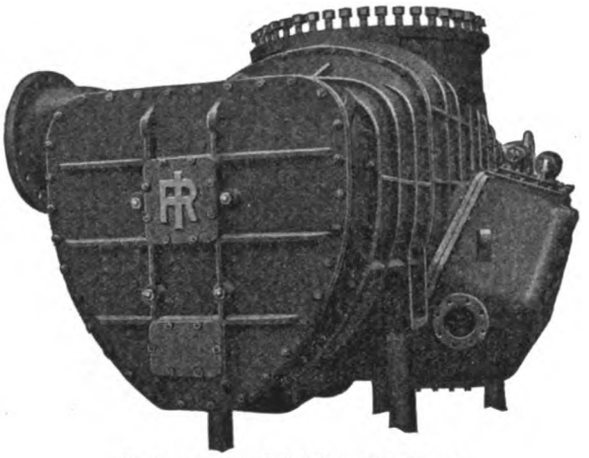
Vertical and horizontal steel air tanks or receivers suitable for a wide range of working pressures built in many sizes for compressors from 15 cu. ft. capacity upwards. All are made of the best steel strongly riveted and tested for safety at the pressures for which they are intended. Bulletin 9102.

Ingersoll-Rand Air Aftercoolers

Aftercooling is the only simple and effective way of taking the moisture out of Compressed Air.

Its use eliminates wet air at the tools, which causes excessive wear by washing out the lubricant, and also prevents freezing up of tools, holes and pipe lines. Aftercooling maintains even pipe line temperature and prevents leaks and breaks consequent to expansion and contraction. Aftercooling traps off the excess compressor lubricant (if any) before it gets into the air receiver or mains.

Compressed air for operating rock drills, sharpeners, hoists, etc., should be dried by aftercooling. Bulletin 9112.



Ingersoll-Rand Surface Condenser

Condensing Plants

The Company is prepared to furnish a suitable condenser for all condensing problems and service conditions. Its line includes the Surface, Barometric and Low-Level Multi-Jet Condensers, together with the Steam Jet Vacuum Pumps.

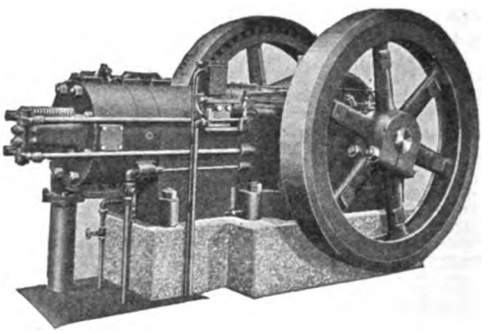
Ingersoll-Rand Surface Type Condensing Plants consist of a surface condenser, Cameron Centrifugal Circulating and Condensate Pumps, and I-R Vacuum Pump equipment. The condensers have greatly reduced tube surface and the elimination of waste tubes is secured by arranging those tubes used in stages and by the use of a separate devaporizer or cooler. This condenser has a distinctive heart-shape shell. The tubes are spaced on wide centers and brought closer together in each lower bank or stage.

A condenser with active steam flow over every tube not only results in a reduced total surface required, but also has the advantage of maintaining a uniformly high condensate temperature by keeping the condensate from all tubes in contact with active steam.

High water velocities with a suitable tube diameter have a tendency to reduce fouling and scaling of the tubes. In the I-R Surface Condenser, by the use of a single pass arrangement, high water velocities are readily obtained without excessive friction.

The residual air and steam from the bottom row of tubes is finally drawn up into the devaporizer or cooler mounted on the side of the shell proper. This cooler is fitted with cast iron grids whose surfaces are particularly adapted to devaporize and cool the air before it is finally drawn into the vacuum pump.

The withdrawal of non-condensables from the bottom of the condenser with the use of a multi-stage tube arrangement and correct shaped shell, insures an active flow of steam over every tube and precludes the possibility of pocketing and stagnation. The elimination of waste tubes in this way represents a large saving in maintenance and renewal costs.



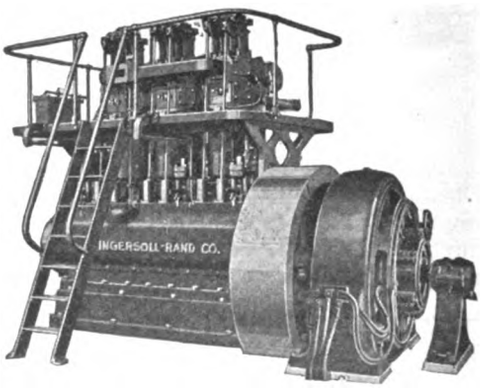
Price Type "PO" Horizontal Oil Engine

Oil and Gas Engines

Price Type "PO" Oil Engine is of the horizontal, single-cylinder, single-acting, direct-injection type operating on the four-stroke cycle and is available in 50 and 100 B.H.P. sizes.

Complete atomization is obtained without the use of high pressure air and by the direct-injection of the fuel, and ignition is at all times by heat of compression only. In fact, the heat of compression is sufficient to ignite the fuel when the engine is cold. Other features are the enclosed and oil-tight crank case; the pressure lubrication system for oiling all important bearings including cam rollers; the continuous filtration of lubrication oil; and the completely water-jacketed cylinder barrel and heads.

Where an oil engine is necessary with over 100 B.H.P. the Company offers its Price-Rathbun Vertical Engines. These are built with three or more cylinders and are available in from 105 to 1,000 B.H.P. sizes.



Price-Rathbun Vertical Oil Engine

The Company's line of horizontal and vertical gas engines will furnish satisfactory power for all general purposes. The range of sizes include the following machines:

I-R Single-Cylinder Horizontal Gas Engine, in 55 and 135 B.H.P. sizes.

Price-Rathbun Vertical, Multi-Cylinder Natural and Producer Gas Engines, in from 75 to 1,400 B.H.P. sizes.

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BURY COMPRESSOR COMPANY

Main Office and Works
1742 Cascade Street, ERIE, PA.

Manufacturers of

Air and Gas Compressors and Vacuum Pumps

Products

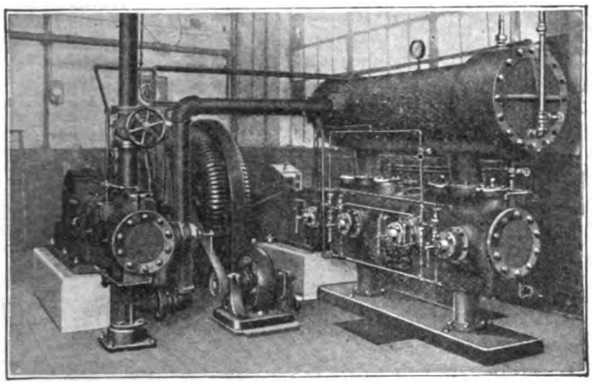
Air and Gas Compressors, steam or motor driven.
Vacuum Pumps, steam or motor driven.

Compressors and pumps are built for all capacities, all pressures, and to meet any engineering requirements.

Also manufacturers of Air Receivers and After Coolers.

Bury Class VCCE Compressors

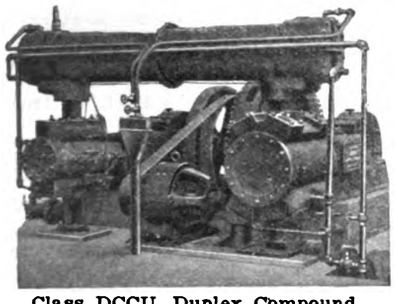
A 2-stage, 3-cylinder, variable volume type (patented). Operates at same efficiency at ¼, ½, ¾ and full load at 1 pound variation in pressure. Lowest input horse-power per cubic foot actual air delivered. Motor or belt drive.



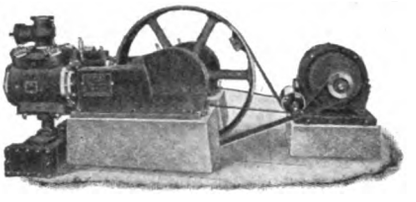
Class VCCE 2-Stage, 3-Cylinder, Variable Volume Compressor, with Synchronous Motor on Shaft
Capacity, 300 to 10,000 cu. ft. per min.

Bury Class DCCU and CCB Compressors

Duplex compound type, belt or motor driven.



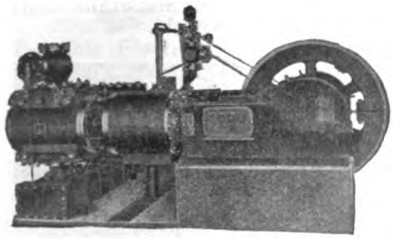
Class DCCU, Duplex Compound, Variable Volume Compressor
Capacity, 450 to 6000 cu. ft. per min.



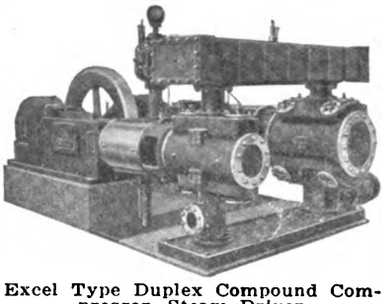
Class CCB Duplex Compound Compressor, Belt Driven
Capacity, 450 to 1500 cu. ft. per min.

Bury Class CCS and Uniflow Compressors

Duplex compound type, steam driven.



Class CCS Duplex Compound Compressor, Steam Driven
Capacity, 450 to 1500 cu. ft. per min.

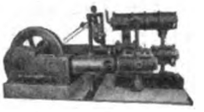


Excel Type Duplex Compound Compressor, Steam Driven
Capacity, 450 to 6000 cu. ft. per min.
Highest steam economy

Bury 3-Stage, Tandem and Duplex, High Pressure Compressors

Steam Driven

Belt Driven



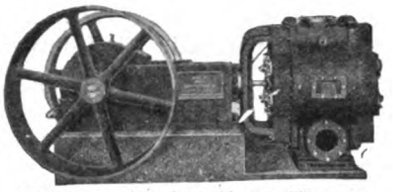
Steam Driven

3-Stage, Tandem and Duplex, High Pressure Compressors
Capacities, 5 to 1000 cu. ft. per min., up to 2000 lbs. pressure

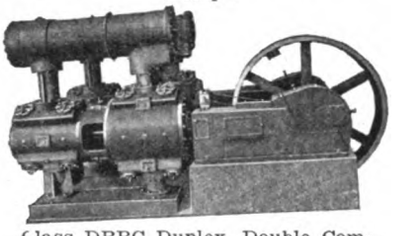
Bury Vacuum Pumps

Single cylinder type built steam or belt driven. Duplex double compound type built steam or belt driven or with synchronous motor on shaft. Specially suitable for glass factories. Installed at:

Hazel-Atlas Glass Co.
Macbeth-Evans Glass Co.
Maryland Glass Corp.
American Bottle Co.
Owens Bottle Co.
Federal Glass Co.



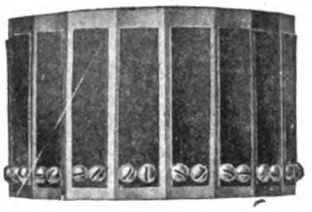
Class VL Single-cylinder Vacuum Pump



Class DBBC Duplex, Double Compound, Vacuum Pump

Bury Patented Pyramid Box Plate Valves

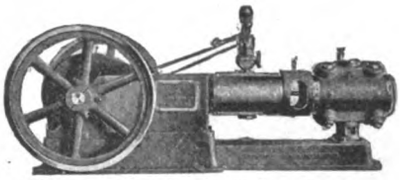
Have 50% greater area than any other type of valve. No tension springs. No buffer plates. Durable as the Pyramids. Silent as the Sphinx.



Pyramid Box Plate Valve

Bury Single-Stage Compressors

Class L Single-stage Compressor, Belt Driven
Capacity, 38 to 1000 cu. ft. per min.



Class LS Single-stage Compressor, Steam Driven
Capacity, 50 to 1500 cu. ft. per min.

Catalogues

Catalogues supplied on request.

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CHICAGO PNEUMATIC TOOL CO.

Chicago Pneumatic Bldg.
6 East 44th Street, NEW YORK

SALES AND SERVICE BRANCHES ALL OVER THE WORLD

Products

Air Compressors — Gas, Oil, Gasoline, Steam, Belt and Motor Driven; Vacuum Pumps and Gas Compressors; Receivers and Aftercoolers; Semi-Diesel Oil Engines; Gas and Steam Engines; Little Giant Air Hoists for Mine and Shop; Air and Electric Rock and Coal Drills; Boyer Pneumatic Hammers for Riveting, Chipping, etc.; Little Giant Electric Tools; Air Hose; Accessories.

Chicago Pneumatic Air Compressors

Chicago Pneumatic air compressors are built in over 500 distinct sizes and types. Standard sizes are built for steam, belt, electric motor, oil, gas or gasoline engine drive and in single, duplex and duplex-tandem types.

Vital Points of Design

An outstanding feature which distinguishes the "air end" of all Chicago Pneumatic Compressors is the "Simplate" flat-disc air valve.

Operation is silent and no valve lubrication is necessary. Highest mechanical and volumetric efficiencies are obtained and absolute dependability is insured. Construction of air cylinder is simplified, floor space minimized and cost of installation lessened, as unusually large capacity is obtained per unit weight of machine.

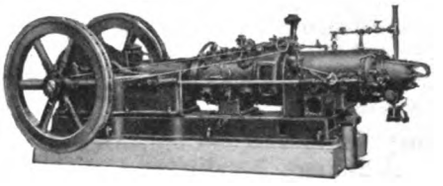
Component Parts of a "Simplate" Valve.

All Chicago Pneumatic Compressors are of totally enclosed frame construction, have exceptionally liberal bearing surfaces, are automatically lubricated, have automatic regulation insuring maximum power economy under varying load conditions and are of modern, rugged design throughout.

Class N Compressors

Represent the highest development yet attained in the construction of compressors of small and medium capacities. Built in single-stage, steam, belt, fuel-oil, gas and gasoline engine types; capacities of belt and steam driven units from 69 to 1197 cu. ft. per minute.

The single-unit oil engine driven machine has come into wide favor due to its low cost of operation, along with the greater availability of fuel oil as compared to coal in many mining regions. Available in tank-mounted, skid-mounted or stationary units — all of which operate successfully on low grade fuel oils under widely different climatic conditions. Capacities up to 658 cu. ft. per min. Bulletin 607.

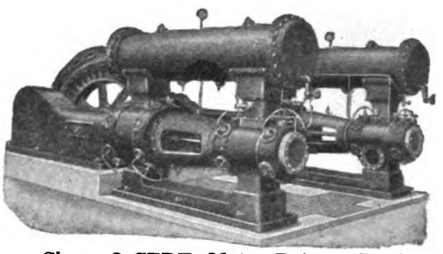


Class N-SO2 Fuel Oil Engine Driven Air Compressor. Note simplicity and compactness. Available also in skid and tank-mounted portable types.

The same style units, both portable and stationary, are built for operation on gas and gasoline. Ask for Bulletin 34-Y.

Class O Compressors

These machines are designed to meet conditions requiring units of medium and large capacities. They are built in six standard strokes from 10 to 21 in., both single and two-stage, and in both duplex and duplex-tandem types, for operation by belt, short-belt-electric motor, direct-connected electric motor, and steam. Capacities extend from 500 to 10,000 cu. ft. of air per min. Bulletin 400 contains full information.



Class O-CTDE Motor-Driven Duplex-Tandem Air Compressor.

Air Receivers and Aftercoolers

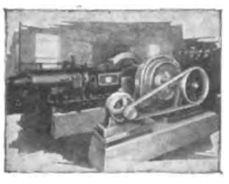
Air receivers are made in vertical and horizontal types for any compressor capacity. Aftercoolers are made in vertical type, with charcoal iron or brass cooling tubes, for compressor capacities of from 100 to 5,000 cu. ft. of free air per minute. Bulletin 657.

"Giant" Semi-Diesel Oil Engines

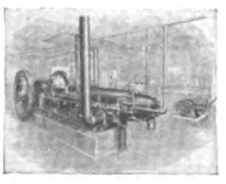
Giant Semi-Diesel oil engines are the most economical form of isolated plants for power from 12 to 200 h.p. They have the overall operating economy of the full Diesel type without its complexity, the dependability of the steam engine without its costly auxiliaries, and the ability to operate successfully and economically on low-grade fuels.

Vital Points in Design

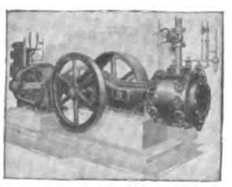
Giant Semi-Diesel engines are built with the cylinder horizontal—all parts in the crank case are accessible, piston can be removed through head end of cylinder and crank shaft can be taken out without removing fly-wheels.



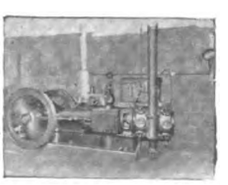
200 H. P. Duplex Type Giant Oil Engine Driving A.C. Generator.



Class N-SO2 Fuel Oil Driven Compressor. Capacity 300 cu. ft.



Class N-SBE Short Belt Motor Driven Compressor. Capacity 534 cu. ft.



Class N-SS Steam Driven Compressor. Capacity 549 cu. ft. per min.

Class O-CTDE Duplex-Tandem Compressor. Capacity 3460 cu. ft. per min.

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SULLIVAN MACHINERY COMPANY

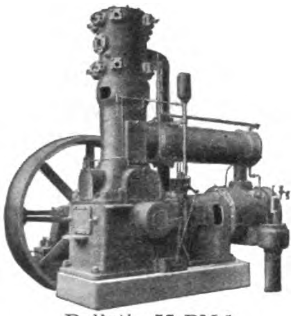
129 South Michigan Ave., CHICAGO, ILL., U.S.A.

DOMESTIC SALES OFFICES
Birmingham, Boston, Butte, Claremont, N. H., Cleveland, Dallas, Denver, Duluth, El Paso, Huntington, W. Va., Joplin, Knoxville, New York, Pittsburgh, St. Louis, Salt Lake, San Francisco, Spokane.

FOREIGN SALES OFFICES
Algiers, Brussels, Calcutta, Christiania, Durban, Natal, Havana, Lima, London, Madrid, Mexico City, Paris, San Juan, Santiago, Shanghai, Sydney, N.S.W., Tokyo, Toronto, Tunis, Turin, Vancouver.

Sullivan Products

Air Compressors; Air Lift Pumps; Diamond Drills; All-Hammer Drill Sharpeners; Drill Steel Furnaces; Forge Hammers; Ironclad Coal Cutters; Rock and Hammer Drills; Quarrying Machinery; Contractors for Diamond Core Drilling; Turbinair Portable Hoists.


Bulletin 77-BMC

Sullivan Air Compressors

There's a Sullivan Compressor just right as to size, type and drive, to render efficient, dependable air power service for your mine. Many of these, both large and small, are now obtainable from our warehouses.

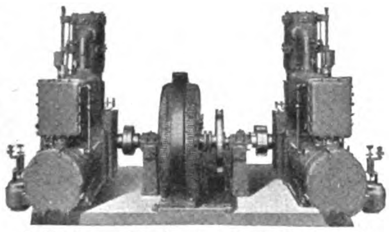
Angle Compound

The Angle-Compound Compressor,shown here, is more popular than ever—capacities, 400-1370 cu. ft., belt or direct motor drive. Plate "Finger" Valves, automatic lubrication.

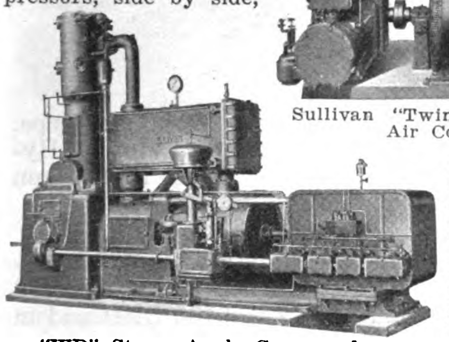
Sullivan High Duty Steam Driven Angle Compound Compressors, "WD" secure high economy by attaching a "direct flow" Sullivan 4-valve center exhaust steam cylinder to the low pressure air end of the angle compound compressor. An entirely new type.

Sullivan "Twin-Angle-Compound" Air Compressors

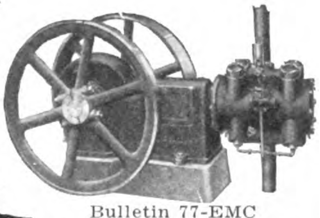
Two separate, complete, two-stage angle compressors, side by side,


Sullivan "Twin-Angle-Compound" Air Compressor

driven by one common belt pulley or direct connected motor. When the demand is less than half the capacity of the compressor, for any extended period,

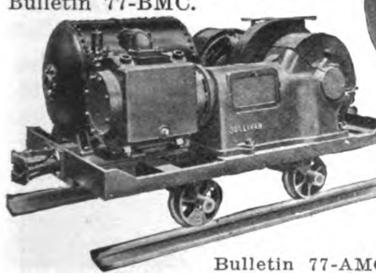

"WD" Steam Angle Compound Unit. Bulletin 77-GMC

one unit may be uncoupled, allowing the other to run at full efficiency. Capacity 800-2700 ft. Bulletin 77-BMC.


Bulletin 77-EMC

Single Steam or Belted Compressors

"WA-6" and "WG-6", range from 60 to 500 ft. capacity, are splash oiled and have "Wafer" valves.


Bulletin 77-AMC

Portable Electric

"WK-26" Mine Car, motor-driven Compressors, 50-250 ft. capacity form a complete, independent, automatic underground air supply.

SULLIVAN STEAM-DRIVEN VACUUM PUMPS, CLASS "WA-61"

Size, Inches	R. P. M.	Displacement Per Rev.	Displacement Per Min.	I. H. P. at Peak Load, atmospheric discharge	Overall Dimensions Ft. In. Length	Overall Dimensions Width	Piping Sizes, Inches: Steam Steam	Steam Exhaust	Air Inlet	Air Discharge	Air Jacket
7x18x 8	260	2.34	610	24	9-2½	2-8	1½	2	5	5	½
9x22x10	235	4.39	1032	41	10-9½	3-5	2	2½	7	6	½
11x21x12	220	4.80	1058	42	12-6½	4-1	2½	3	7	6	¾
11x26x12	220	7.37	1620	65	12-7	4-1	2½	3	8	7	¾

"WJ-3" AIR COMPRESSORS: ANGL-COMPOUND, BELT DRIVEN

Cylinder Sizes, Inches Diameter: L. P.	H. P.	Stroke, Inches	Net Displacement Cubic Feet per Minute	Revolutions per Minute	Horse Power at 100 Pounds Pressure	Over All Dimensions Feet—Inches: Length	Width	Height above Bottom of Bed Plate	Belt Pulley: Diameter Feet—Inches	Face, Inches	Piping: Discharge Opening Inches	Jacket, Inlet and Outlet, Inches
14	8¾	10	478	270	77	8-10	4- 0	7- 1½	5-10	10	3	1
16	9¾	10	625	270	103	8-11¼	4- 2⅜	7- 2½	5-10	10	3	1
17	9¾	12	784	250	125	9-11½	5-11½	7-11½	6- 4	15	3½	1¼
18	11	14	982	240	158	11- 2½	7- 6½	9- 7½	6- 8	19	3½	1½
20	12	14	1214	240	195	11- 4½	7-10½	9- 9	6- 8	23	4	1½
22	13	14	1469	240	242	11- 7	8- 1	9- 9	6- 8	24	4½	1½
24	14½	16	1730	210	275	12- 2	10- 0	11- 8¼	6-10	35	8	1½

DETAILS OF "WG-6" AIR COMPRESSORS, SINGLE STAGE, BELT DRIVEN

Size Cylinder: Diameter, Inches	Stroke, Inches	Displacement Cu. Ft. per Minute	Displacement, Cu. Ft. per Rev.	Speed, R.P.M.	Air Pressure, Pounds	Horse Power at This Pressure	Over All Dimensions: Length Feet—Inches	Width Feet—Inches	Height Above Bottom of Bed Plate, Ft.—Ins.	Fly-Wheels: Diameter, Inches	Width Pulley Face, Inches	Air Piping: Inlet	Discharge	Jacket Inlet and Outlet, Inches
6	6	68	.19	350	120	10.5	4-10½	1-10½	2- 0	30	4½	1½	1¼	½
7	6	93	.26	350	100	12.5	5- 0	1-10½	2- 0	30	4½	2	1½	½
8	6	122	.34	350	50	14	5- 5½	1-10½	2- 0	30	4½	2½	2	½
8	8	139	.46	300	120	22.5	6- 3	2- 4½	2- 8	40	7	2½	2	½
9	8	176	.58	300	100	25	6- 4	2- 4½	2- 8	40	7	3	2½	½
10	8	218	.72	300	50	25.5	6- 4	2- 4½	2- 8	40	7	3½	3	½
10	10	236	.90	260	120	38	7- 5	3- 0	3- 4	50	10½	3½	3	½
11	10	286	1.09	260	100	45.7	7- 6	3- 0	3- 4	50	10½	4	3½	½
12	10	340	1.30	260	100	53.8	7- 7	3- 0	3- 4	50	10½	4	3½	½
14	10	463	1.76	260	50	57.5	7- 7	3- 0	3- 4	50	10½	5	4	¾
12	12	377	1.57	240	120	67	8-10	3-11	3-10½	60	14½	4	3½	½
14	12	513	2.13	240	100	90	8-10	3-11	3-10½	60	14½	5	4	½
16	12	670	2.79	240	50	87	8-11	3-11	3-10½	60	14½	6	5	¾

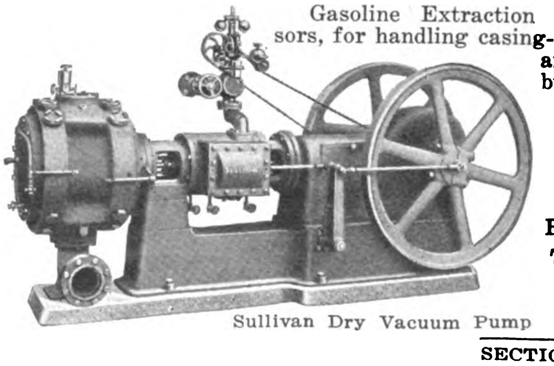
"WD" DIRECT FLOW STEAM ANGLE COMPOUND AIR COMPRESSORS

Cylinder Diameter, In.: Steam	Low Press. Air	High Press. Air	Stroke, Inches	Displacement, Cu. Ft. per Min.	R. P. M.	Indicated H. P. at 100 lbs. air Pressure	Overall Dimensions, Feet—Inches: Length	Width	Height	Diameter, Ft. Fly-Wheel	Piping, In.: Steam	Exhaust	Air Outlet	Water Jacket
20	20	12	14	1138	225	190	17- 9	8-3	10-8	8	5	8	6	1½
24	24	14½	16	1730	210	285	19-10	9-3	12-2	9	6	10	8	1½

Sullivan Dry Vacuum Pumps

Sullivan steam- and belt-driven dry vacuum pumps are available in a number of convenient sizes. They are equipped with Sullivan Wafer Valves on the vacuum cylinders, and all main working parts are fully enclosed and are lubricated by the splash system. Bulletin 78-AMC.

Gasoline Extraction Compressors, for handling casing-head gas, are also built.


Sullivan Dry Vacuum Pump

Ask for Bulletin 78AMC.

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Worthington Pump and Machinery Corporation

Executive Offices
115 Broadway, NEW YORK

For List of Works and Offices, See Page 493

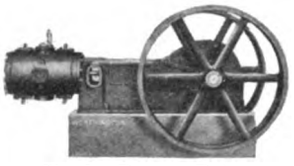
Air Compressors and Oil Engines

Products

Air Compressors; Kerosene Engines; Snow Oil Engines; Water Turbines and Wheels; Receivers and Aftercoolers. For other products see Pages 165, 166, 167, 463, 493, 626 and 741.

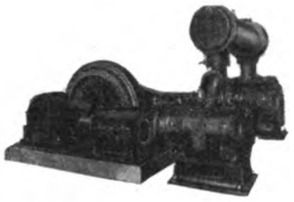
Air Compressors

Worthington makes Air Compressors with electric, steam or belt drive. The salient feature of all these types is the FEATHER (Reg. U. S. Pat. Off.) Valve, which is the most efficient and durable valve yet designed for air compressors.

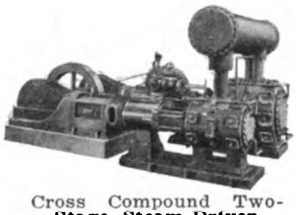


Single Power Driven Air Compressor

This valve consists of strips of light steel, restrained but not rigidly secured at the ends, and free to lift from the seat in the middle to permit the passage of air. Each element of the valve, therefore, consists of a light, thin, rectangular metal strip, covering, when seated, a somewhat smaller slot. The valve seats on a perfectly plain ground surface, is of such length that its flexure, while slight, is also perfectly free and uniform, and is of such flexibility as to lie, when under pressure, in full contact with seat at every point. The valve has no springs to break, no plates to crystallize, and no points of rigid connection with its seats.



2470 Cubic Feet Compressor, Motor-Driven



Cross Compound Two-Stage Steam-Driven Compressor

The valve seats by contact and not by impact.

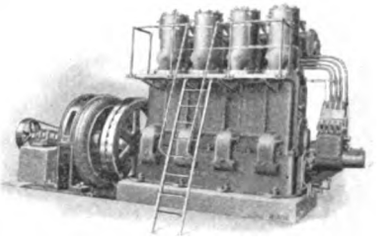
FEATHER Valve With Cover Removed

Worthington Horizontal Kerosene Engine

Built in single cylinder type in 1½, 2½, 4, 6, 8, 10 and 15 H. P. sizes. All are hopper cooled and equipped with throttling governor with the exception of the 1½ H. P. size which operates on gasoline only and is equipped with hit and miss type of governor. Sizes from 10 to 25 H. P. cooled by running water or siphon system.

Worthington Diesel Engine, Two-Cycle Solid Injection Type

The engine shown is of vertical two-cycle solid fuel oil injection type with full Diesel combustion. It is of the cross head design, sizes from 30 to 450 H.P., 1 to 6 cylinders.



Worthington Diesel Engine, Two-Cycle Solid Injection Type

Snow Type Horizontal Oil Engine

Built in 1, 2 and 3 cylinders, in sizes 65 to 600 H.P. It is of the horizontal four-cycle full Diesel cross head type, the construction in general following that of the 150 H. P. size shown herewith. Equipped with compressor for starting and for injecting the oil. Feather Valves are a distinctive feature of the compressor.

150 H. P. Snow Type Single Cylinder Engine

Hydraulic Turbines

Are of the well known Francis Reaction Type. Duplicate wheels and repairs for the "Victor" Hydraulic Turbine—acquired from the Platt Iron Works—can be supplied.

For Low Head Service From 10 to 50 Feet

A complete line of vertical and horizontal standard wheels of the open flume as well as enclosed casing type, in output from 32 to 6400 BHP and in speed from 385 to 275 RPM. Noteworthy features are the rigidity, ruggedness and simplicity of design to insure reliability even under unfavorable conditions, ease of erection and accessibility for inspection or repairs.

For Medium Head Service From 50 to 300 Feet

A complete line of standard wheels of both the vertical and horizontal type in output from 50 to 5000 BHP and in speed from 900 to 240 RPM. The entire line can be equipped with either spiral or cylindrical casings as particular conditions may dictate.

For High Head Service up to 1,000 Feet

Runners are built to insure high efficiency, increased power output and freedom from wear due to eddy currents. Gate mechanism is of the "outside" type. Water channels are free from links and joints, hence do not depend on water for lubrication. Draft tube design insures freedom from vibration.

The governor design—evolved through long experience—meets all requirements of regulation and insures continuous service.

Special designs submitted to meet existing conditions.

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DE LA VERGNE MACHINE COMPANY

2107 East 138th Street, NEW YORK CITY

Manufacturers of Oil Engines for Stationary Service

Also Refrigerating and Ice-Making Machinery

De La Vergne Oil Engines:

Sizes of De La Vergne heavy duty Oil Engines range from 40 to 1080 H.P. per unit. All engines developed to operate on practically any petroleum oil obtainable in the United States or Mexico.

Type "DH": Range of sizes 40 to 130 H.P. horizontal cylinders.

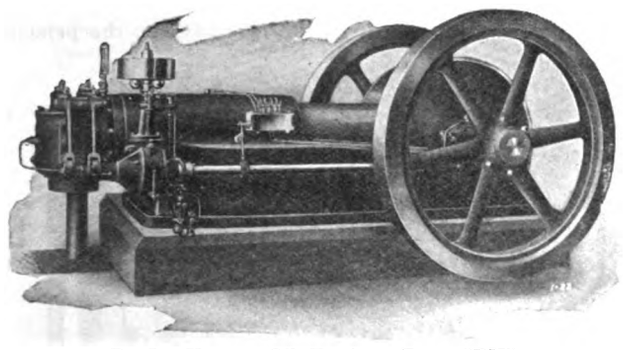
Fuel Guarantee:

40 to 80 H.P. Sizes

Full	Load:	0.55 lbs.	per B.H.P. Hr.
¾	Load:	0.55 lbs.	per B.H.P. Hr.
½	Load:	0.65 lbs.	per B.H.P. Hr.

65 and 130 H.P. Sizes

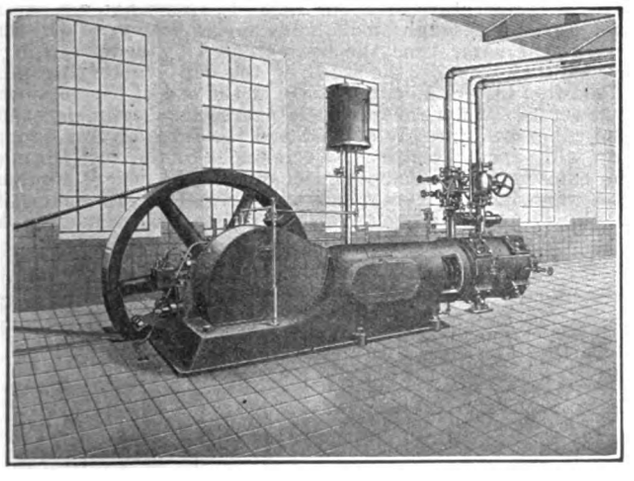
Full	Load:	0.50 lbs.	per B.H.P. Hr.
¾	Load:	0.50 lbs.	per B.H.P. Hr.
½	Load:	0.55 lbs.	per B.H.P. Hr.



De La Vergne Oil Engine—Type "DH"

This type is an improvement as regards fuel economy and grade of oil over former and well known Hornsby-Akroyd Oil Engine. Operates at slow speeds, on the four-stroke cycle; no electric ignition. Engine extremely simple and reliable.

Logical prime mover for Municipal Power and Lighting Plants, small Pipe Line Pumping units and auxiliaries; small isolated industrial plants and for auxiliary use in plants where larger capacity engines are used as prime movers.



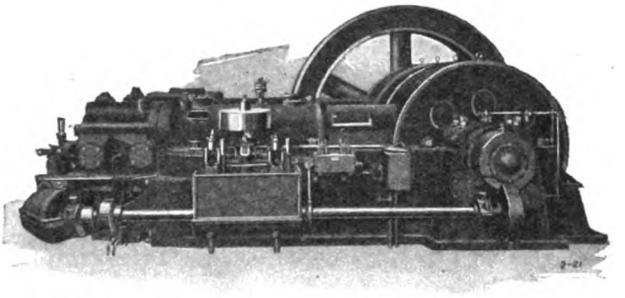
De La Vergne High Speed Refrigerating Machine

De La Vergne-Diesel Engine

Types "FD" and "SI": Range of sizes 100 H.P. and up in horizontal cylinder arrangements of one to six.

Fuel Guarantee:

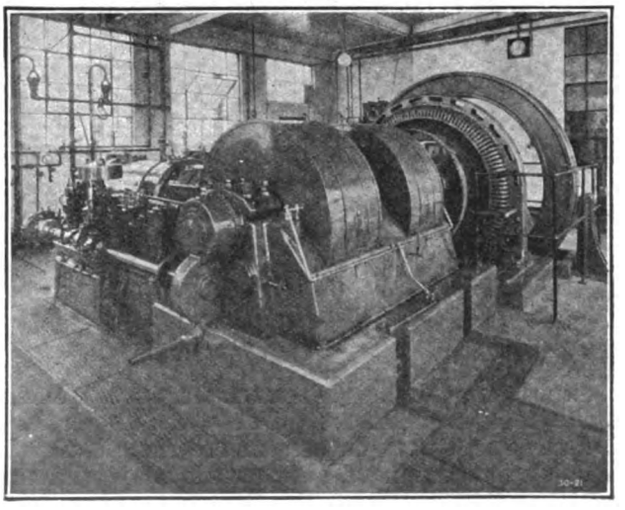
Full	Load:	0.45 lbs.	per B.H.P. Hr.
¾	Load:	0.45 lbs.	per B.H.P. Hr.
½	Load:	0.50 lbs.	per B.H.P. Hr.



De La Vergne Oil Engine—Type "SI"

Operates at low speeds and actually obtains fuel economy of .40 lbs. per B.H.P. Hr. at full load. Engine runs on the four-stroke cycle and is the direct result of oil engine manufacturing experience of over 25 years. Engine is extremely reliable, durable and economical. Logical prime mover for the larger power plants where the oil engine is applicable.

The Type "SI" has the same good points as the "Air Injection" Diesel Engine, i. e., high fuel economy, wide range of fuel and immediate starting, and in addition, eliminates the blast air compressor and its driving mechanism, also the cam-operated spray valve. This results in higher mechanical efficiency, lower cost of maintenance, lower air pressure for starting. The MAXIMUM SIMPLICITY OF ENGINE CONSTRUCTION.



A Typical De La Vergne Oil Engine Installation. 200 H.P. Type "SI" at Boston Gear Works, Norfolk Downs, Mass.

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DODGE SALES & ENGINEERING CO.

MISHAWAKA, INDIANA

Manufacturers of Oil Engines

For List of Engineering and Sales Offices See Pages 210 and 650

DODGE

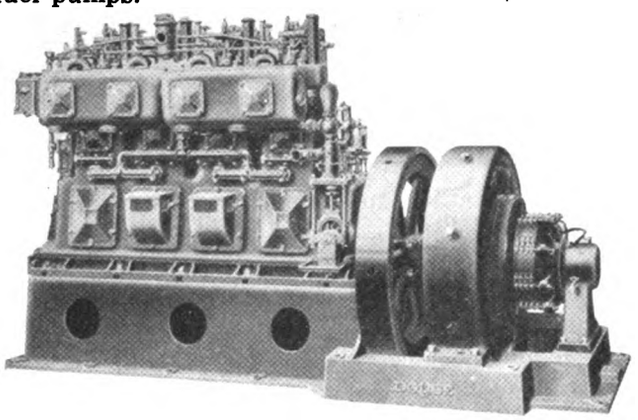
Products

Dodge Heavy Oil Engines.

For Power Transmission Machinery see pages 210, 211 and 212; for Elevating and Conveying Equipment, see pages 650 and 651.

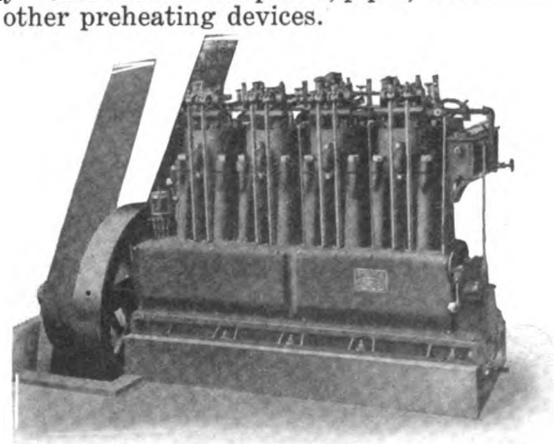
The Dodge Heavy Oil Engine

The Dodge engine is built on the improved Diesel principle. This means that it has all of the features of economy and reliability of the larger types but without the objectionable features such as multi-stage air compressors and high pressure fuel pumps.



These engines use low priced fuel oils on a guaranteed consumption basis of .5 of a pound of fuel oil per B. H. P. hour.

Combustion is accomplished by compression only—there are no hot plates, pipes, electric torches or other preheating devices.



Interchangeability is developed in the Dodge engine to a high degree. The one cylinder 12½ H. P. engine differs only from the six cylinder 75 H. P. size in length of base, crank shaft and cam shaft.

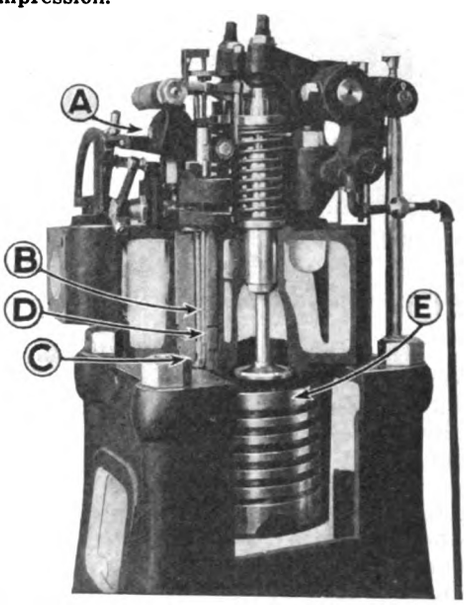
Lubrication is provided by a positive mechanically driven force feed lubricator which supplies all cylinders, main bearings, connecting rods. Crank pins are lubricated from the force feed lubricator by the use of oil rings. The oil feed to bearings can be easily and accurately adjusted.

Dodge Heavy Oil Engines can be furnished either for belt drive, arranged for direct connection to generators or complete with generator. They are also built in marine types in the same range of size and are adapted for service on tugs, freighters, dredges, etc.

These units offer an economical and satisfactory solution of the additional power problem without making necessary the re-arrangement or addition to central station equipment. They are especially adapted for mine lighting plants and other auxiliary service as well as for main power within their range of sizes.

Method of Operation

The Dodge Four-Cycle Engine operates on the principle of ignition by compression.



Fuel oil from the supply tank is fed through a pipe and inlet (A) past needle valve (B) (controlled by the governor) to the fuel inlet valve (C), which is opened by a rocker arm during the inspiration stroke and admits the fuel to the cup (D), which extends down to the cylinder.

During the inspiration stroke pure air only is taken into the cylinder and on the compression stroke this air is brought to a pressure of 450 pounds, which gives a temperature of about 1000° F. This hot air enters fuel cup (D) through small holes at the bottom of the cup and at the same time the heat created by compression is transmitted through the walls of the cup—vaporizing part of the fuel inside the cup, so that at the end of the compression stroke (when the piston is nearest the cylinder head) this vapor will forcibly expand and the force of this expansion will spray the still fluid remainder of the fuel through the holes into the combustion chamber (E), where combustion immediately takes place and drives the piston on its power stroke; the piston then returns on its exhaust stroke and the cycle is complete.

STATIONARY ENGINE SPECIFICATIONS

Size B. H. P.	Number of Cylinders	R. P. M.	Net Weight, Lbs.	Approximate Wts. and measurements boxed for export	
				Gross Weight, Lbs.	Measurements, Cu. Ft.
12½	1	450	3000	3900	90
25	2	450	4000	5000	110
37½	3	450	5100	6200	130
50	4	450	6200	7500	150
75	6	450	8400	10000	190

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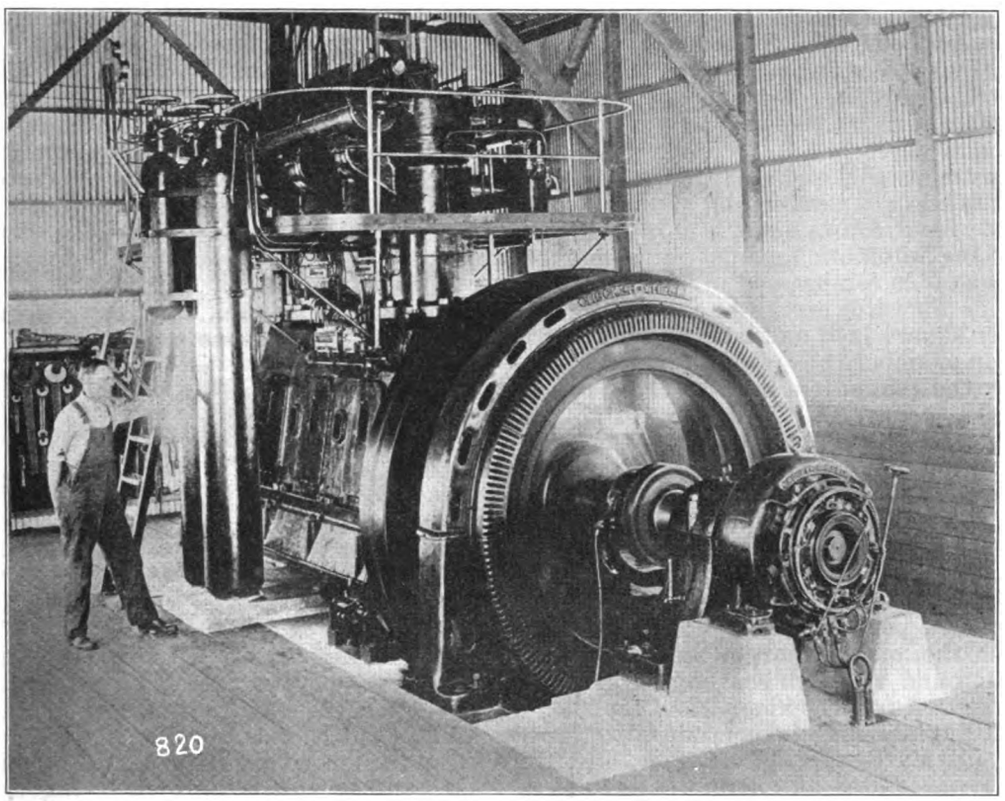
DIESEL OIL ENGINES



300 Brake Horse Power Diesel Oil Engine in a Power Plant for a Mine

A 3-B-33 engine rated at 300 brake horse power at 200 R.P.M. connected to a 200 K.W. 60-cycle alternating current generator with direct connected exciter, furnishing power for a western copper mine, is shown in the picture above. The complete plant, except for the tanks in which the fuel oil is stored, is shown.

The full economy of the Diesel type engine has an enhanced value in plants remote from railroads where transportation costs are high. It is possible to bring in enough oil fuel for this plant for several days running by a single trip of a motor truck. This is a great advantage where continuous operation is important.

The small amount of water required by a Diesel type of engine is a great advantage in a mining plant where water is apt to be scarce.

In such a case it is usual to use a cooling tower or spray pond, so the water can be cooled and used over and over again. The loss, due to the spraying for the cooling depends on the arrangement of the tower or pond, the amount of cooling and the wind. This loss would amount to an average of perhaps two gallons a minute for a power plant of this size at full load to make up the loss due to cooling.

For mining service where the load is very variable, the flat economy curve of the Diesel engine is very advantageous, as it enables high efficiency to be obtained even in spite of the variable nature of the load.

SIZES AVAILABLE

B. H. P.	Speed R. P. M.	Actual K. W. of Generator	No. of Cylinders	Type and Size of Engine	Code Word for Engine
100	257	65	2	2-B-25	WESCOTT
150	257	100	3	3-B-25	WESTERN
200	257	135	4	4-B-25	WESTERLY
300	257	200	6	6-B-25	WESTFALL
200	200	135	2	2-B-33	WELSH
300	200	200	3	3-B-33	WENCH
400	200	275	4	4-B-33	WELKIN
600	200	410	6	6-B-33	WELTER
500	164	350	4	4-A-38	WRANGLE
550	164	385	4	4-B-40	WHIZ
825	164	580	6	6-B-40	WHIZER
665	150	460	4	4-B-44	WIERD
1000	150	700	6	6-B-44	WEDDING
750	150	525	4	4-C-46	WRAP
1150	150	800	6	6-C-46	WRAPPER
1600	106	1135	6	6-C-56	WATERFALL
2140	106	1500	8	8-C-56	WANDERING
2500	90	1750	8	8-C-60	WARBLING

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MUNCIE OIL ENGINE COMPANY

MUNCIE, INDIANA

Export Office—36-40 West 60th St., New York, N. Y., U. S. A.

Manufacturers of

Muncie Crude and Fuel Oil Engines

Made in Sizes 10 to 250 B. H. P.

General Description

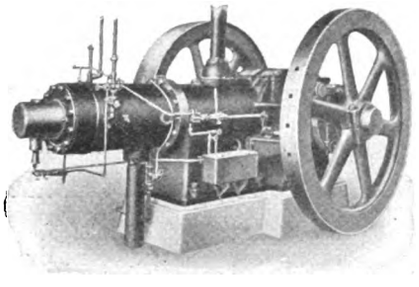
All Muncie Oil Engines are of horizontal type and operate on the two-cycle principle, obtaining the temperature for ignition on the second stroke by means of a hot bulb or igniter head which, on starting, is heated by outside means. When the engine is in operation, the igniter head is maintained at sufficient temperature by the heat of the combustion of the fuel.

The crank case is enclosed, and the front end of the piston is used as a scavenging pump. When on the back stroke it draws air only into the crank case, through the automatic air inlet valve chamber attached. The air is compressed in the crank case on the next, or forward, stroke to a pressure less than 3 lbs. per square inch and is then admitted to the combustion chamber through the transfer ports controlled by the piston. When on the next, or rearward stroke, a charge of fuel is forced in by the governor-driven injection pump through the injector nozzle in the cylinder head, directly onto the igniter spoon in the combustion chamber. Here it is volatilized and ignited by the heat of the igniter head, compression plate and the increasing heat of compression.

The piston, on passing to forward position, uncovers the exhaust ports on lower side of cylinder, through which the burned charge escapes by force of its expansion and aid from scavenging air from crank case admitted before exhaust is complete.

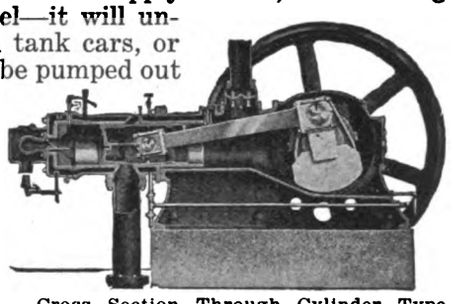
Muncie Oil Engines operate on crude oil and residual fuel oils, distillates, gas oil, kerosene, etc., and are equally as well suited on one of these fuels as another. The economy therefore best obtained is determined on the selection of such fuels of that range as can be most conveniently obtained, and delivered at the most favorable price per gallon.

The fuel consumption is practically the same with one fuel as with another. The choice should be made therefore also with the storage and handling in view, the heavier fuels in colder weather being so protected or stored and supply pipes so enlarged as to avoid difficulty in pumping or delivery from the exposure to winter elements, which always congeals or stiffens the body of any fuel to a certain extent. Fuels should be selected having a cold test to suit the conditions prevailing where installation is made.



Right Hand Rear View 80 H.P. Type "C" Special Heavy Duty Muncie Oil Engine. Note heavy fly wheels as employed on Special Electric Engines.

Fuel Economy—The principal asset of any oil engine—is but one of the many advantages; others deserving attention are: The space saved in the installation; the flexibility of the engine as regards automatic control under varying loads, without personal attention or manual adjustments; the lack of continued or constant attention when once started, other than addition of proper lubricating oil and occasional inspection of mechanical adjustments when not in operation; the ease of effort on the part of operator to get the plant in operation under load quickly; the saving of space for storage of fuel supply—for example, twelve to fourteen weeks supply of fuel oil would occupy the same amount of space as only one weeks supply of coal; the handling of the liquid fuel—it will unload itself from tank cars, or one carload can be pumped out by small power drive pump in a few hours, where storage tank is located above the railroad tank car levels. For delivery to the engine the required fuel is automatically drawn and handled without any work on part of operator. These advantages are offered by any oil engine when properly equipped as is the Muncie Oil Engine.



Cross Section Through Cylinder Type "C" Special Heavy Duty Muncie Oil Engine as made in sizes 40 H.P. and above. Combustion chamber design similar on all sizes.

Muncie Engines are exceptionally adapted where constant service is desired, owing to their simple and heavy construction. They will develop their full rated capacity easily, and will operate on fractional loads, or intermittent loads, very successfully. Owing to the ease and readiness of starting and reliability of operation, they are specially fitted for the operation of mine pumps, air compressors, vacuum pumps, fans, blowers, hoists, conveyors, dredge pumps, gravel pumps, mine or stone crushers, pulverizers, etc. Special electric types of engines are furnished for driving electric generators for power or lighting purposes, for single or parallel operation of alternating or direct current generators, belted or direct connected.

Spare parts are furnished with the engine equipment to replace such parts usually subject to renewal by wear within a year or so. All parts are machined in duplicate and are interchangeable to the finest degree, the minimum of fitting being required.

The main bearings are made of genuine babbitt metal, poured, peined, bored, scraped and fitted to the proper clearance. Connecting rod bronze bushings are cast to special analysis.

Cylinders are cast of close grain, grey iron, especially hardened on the wearing surface by a chilling process giving uniform hardness to permit the wear being subjected to them instead of the cylin-

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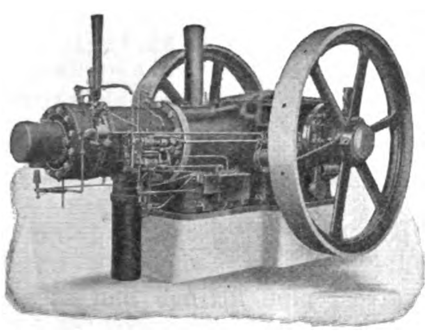
der. Piston rings are concentric, absolutely cylindrical in form after finishing, making a positive gas-tight fit.

The connecting rod is exceptionally strong, being fitted at each end with removable bushings of bronze, made in halves, each being accurately fitted to the bearing housing at the ends.



Right Hand View 100 H.P. Type "C" Special Heavy Duty Muncie Oil Engine.

The friction clutch pulley is carried on an extension shaft which is secured to the fly wheel hub face by means of a flange coupling designed and machined to fit over the extension of crank shaft projecting from fly wheel, aligning it with the crank shaft.

The crank shaft is forged from a solid billet of open hearth steel, accurately machined, and is equipped with counter-balances.

The cooling water is provided by means of a forced circulating system which may be, according to conditions prevailing at installation, either plunger type of pump, belted, geared or eccentric driven or belted centrifugal pump.

As to cost of operation with the Muncie Oil Engine, taking the average from a medium size engine 50 to 100 H. P. and at full load basis you are assured of a cost of power at the following figures:

COST OF POWER PRODUCED

Cost of Fuel Per Gallon	Cost in Cents, BHP Hour	Cost in Dollars, 1,000 BHP Hours
12½c	1.	$10.00
12c	.96	9.60
11c	.88	8.80
10c	.80	8.00
9c	.72	7.20
8c	.64	6.40
7c	.56	5.60
6c	.48	4.80
5c	.40	4.00
4c	.32	3.20

For determining the cost for fractional loads the rate of fuel consumption of same range of size is given below.

PER BRAKE H.P. PER HOUR, USING FUEL OIL 26° TO 28° GRAVITY, (BEAUME)

Load	Pounds	Pints
Full	.6	.643
Three-quarter.	.66	.707
One-half	.78	.836

Note—Oil of from 26° to 28° Beaume gravity will weigh approximately 7.465 lbs. per gal.

GENERAL SPECIFICATIONS OF MUNCIE OIL ENGINES 10 TO 125 B. H. P.
See Special Bulletins for Sizes up to and Including 250 B. H. P.

Type of Design	2BN	3BN	4ANA	4ANB	4ANC	4FCNA	4FCNB	4FCNC	5CNA	5CNB	6CNA	7CNA	7CNB	8CNA	8CNB
Rating H.P.	10	20	25	30	35	40	45	50	55	60	70	80	85	100	125
Bore and Stroke	6½x10	9x13	10x15	10x16	11x16	11x17	12x17	12x18	12x19	13x19	13½x20	15x22	15½x22	16x24	17x25
Speed	375	250	250	250	250	265	250	250	250	240	225	200	200	190	190
Crankshaft Bearings	3x6½	4x8	5x10	5x10	5x10	6¼x16	6¼x16	6¼x16	6½x15	6½x15	7x17	7½x17	7½x17	8½x17	8½x17
Crank Pin	3x3	4x4	5¼x5	5¼x5	5¼x5	6¼x6¼	6¼x6¼	6¼x6¼	6½x6½	6½x6½	7x7	7½x7½	7½x7½	8½x8½	9x8½
Piston Pin	1¾x3	2½x4	3½x5	3½x5	3½x5	3¾x5	3¾x5	3¾x5	4¼x6½	4¼x6½	5x7	5½x7½	5½x7½	6x8½	6x8½
Len. Con. Rod Cen.	30	36	40	40	40	51	51	51	54	54	60	66	66	72	72
Length of Piston	14⅝	17¾	24⅜	24⅜	24⅜	26 7/16	26 7/16	26 7/16	28⅛	28⅛	31⅜	31½	31½	34	34
Exhaust Outlet	4	5	6	6	6	6	6	6	8	8	8	8	8	10	10
Air Inlet	3	4	6	6	6	6	6	6	6	6	6	6	6	8	8
Cylinder to Wall	2-5	3-5	3-8	3-8	3-8	5-5	5-5	5-5	5-10	5-10	6-6	6-10	6-10	7-10	8-10

STANDARD COMMERCIAL BELTED ENGINES—For all ordinary Power Service excepting driving Electric Generators

Type of Design	2BN	3BN	4ANA	4ANB	4ANC	4FCNA	4FCNB	4FCNC	5CNA	5CNB	6CNA	7CNA	7CNB	8CNA	8CNB
Fly Wheel Size	48x3½	60x4½	60x4	69x5½	69x5½	69x5½	72x6	72x6	76x6½	76x6½	82x7	88x8	88x8	96x9½	96x11½
Fly Wheel Weight	350	768	1010	1500	1500	1620	1780	1780	1910	1910	2225	3000	3000	4100	4400
Clutch Pulley	*20x6	16x12	22x12	24x12	28x12	32x12	34x12	36x12	38x12	42x12	48x14	60x14	64x14	72x16	76x18
Outboard Bearing	....	3 3/16x14	3 11/16x12	3 11/16x12	3 11/16x12	3 11/16x16	3 11/16x16	3 11/16x16	3 15/16x16	3 15/16x16	4 3/16x18	4 7/16x18	4 7/16x18	5 7/16x21	5 7/16x21
Floor Space W. x L.	5-0x6-6	8-3x7-11	9-6x8-11	9-6x9-3	9-6x9-3	12-0x10-9	12-0x10-10	12-0x10-10	12-0x11-4	12-0x11-4	12-6x12-3	13-0x13-3	13-0x13-3	15-8x14-7	15-8x14-7
Shipping Weight	2700	5600	8050	9000	9500	14000	15000	16000	17000	18000	22000	26000	27500	32500	36000

STANDARD COMMERCIAL DIRECT COUPLED ENGINES—For all ordinary Power Service excepting driving Electric Generators

Type of Design	2BN	3BN	4ANA	4ANB	4ANC	4FCNA	4FCNB	4FCNC	5CNA	5CNB	6CNA	7CNA	7CNB	8CNA	8CNB
Fly Wheel Size	48x3½	60x4½	60x4	69x5½	69x5½	69x5½	72x6	72x6	76x6½	76x6½	82x7	88x8	88x8	96x9½	96x11½
Fly Wheel Weight	350	768	1010	1500	1500	1620	1780	1780	1910	1910	2225	3000	3000	4100	4400
C. O. Coupling Sym.	B	G	C	C	C	35	35	35	45	45	60	80	80	100	130
Space for Fla. Cou.	4	4 3/16	5	5	5	5	5	5	5⅛	5⅛	5¾	5¾	5¾	6¼	6¼
Outboard Bearing	2 15/16x12	3 3/16x14	3 11/16x12	3 11/16x12	3 11/16x12	3 11/16x16	3 11/16x16	3 11/16x16	3 15/16x16	3 15/16x16	4 3/16x18	4 7/16x18	4 7/16x18	5 7/16x21	5 7/16x21
Floor Space W. x L.	8-2x6-3	9-4x7-6	11-0x8-11	11-0x9-3½	11-0x9-3½	12-4x10-9	12-4x10-10	12-4x10-10	12-6x11-4	12-6x11-4	13-4x12-3	13-10x13-3	13-10x13-3	14-9x14-7	15-0x14-7
Shipping Weight	2800	5600	8250	9250	9850	14500	15500	16500	17500	18500	22500	26600	28000	32700	36800

SPECIAL ELECTRIC ENGINES BELTED FROM WIDE FACE FLY WHEEL—For driving Electric Generators

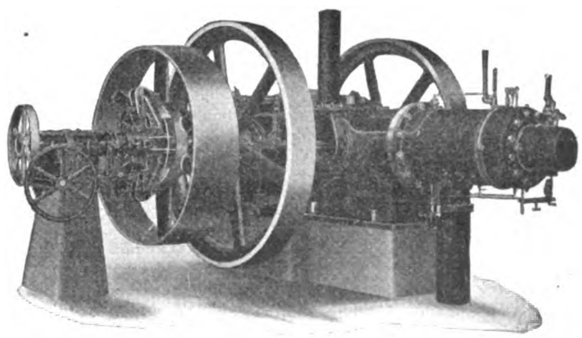
Type of Design	2BN	3BN	4ANA	4ANB	4ANC	4FCNA	4FCNB	4FCNC	5CNA	5CNB	6CNA	7CNA	7CNB	8CNA	8CNB
L.H. Fly Wheel Size	48x4½	60x7¼	69x9½	69x9½	72x9½	72x9½	76x10½	76x10½	76x12½	76x12½	82x12½	88x14½	88x14½	96x18	96x20
L.H. Fly Wheel Wgt.	544	1555	1740	1740	2252	2328	2700	2700	2985	2985	4200	6935	6935	7100	8100
R.H. Fly Wheel Size	48x3½	60x4	69x5½	69x5½	72x6	72x6	76x6	76x6	76x6	76x6	82x5¼	88x6¾	88x6¾	96x10¼	96x12
R.H. Fly Wheel Wgt.	350	867	1500	1500	1602	1678	2160	2160	2160	2160	3225	5000	5000	5100	5500
Nom. Kilo. Rating	6⅔	13⅓	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40	46⅔	53½	56⅔	66⅔	83⅓
Outboard Bearing	....	3 3/16x14	3 11/16x12	3 11/16x12	3 11/16x12	3 11/16x16	3 11/16x16	3 11/16x16	3 15/16x16	3 15/16x16	4 3/16x18	4 7/16x18	4 7/16x18	5 7/16x21	5 7/16x21
Floor Space W. x L.	3-8x6-2	6-6x7-6	8-3x9-3	8-3x9-3	8-3x9-4½	10-3x10-10	10-3x11-0	10-3x11-0	10-3x11-4	10-3x11-4	10-10x12-3	11-3x13-3	11-3x13-3	12-7x14-7	12-9x14-7
Shipping Weight	3000	6300	9250	9750	10600	14500	16000	16900	17900	18900	24500	31500	32500	35300	39700

*On 10 H. P. has clutch pulley bolted to fly wheel and has no extension shaft or outboard bearing.

NOTE:—On 40 H. P. and all larger sizes there is furnished Complete Air Starting Outfit of liberal proportions, Fuel Oil Blast Burner, Auxiliary Fuel Lift Pump and Tank complete with fittings. All engines furnished Left Hand Drive unless otherwise specified on order. (Standing at cylinder end facing fly wheels, Drive will be to the left).

The standard of equipment includes:

1. All the necessary auxiliaries to the engine and the usual list of spare parts and wrenches, fittings, grease cups, etc.
2. Mechanical force feed lubricator and fittings complete.
3. Water circulating pump and fittings.
4. Auxiliary fuel pump and tank and fittings.
5. Air starting equipment complete, compressor, pulley, belt, tanks and fittings, with auxiliary gasoline engine for operating compressor.
6. Exhaust fittings complete from cylinder to cast iron muffler and including cast iron muffler and stack.
7. Complete piping and fittings for air, oil, and water supply and drain purposes.
8. Driving apparatus to suit the type of installation:
   (a) Friction Clutch Pulley for Standard Commercial Service.
   (b) Friction Cut-off Coupling for Standard Commercial Direct Conected Service.
   (c) Heavy Fly Wheels with wide face for belting to generators.
   (d) Heavy Wheels and special extension shaft and coupling for rotor for direct connecting to generators.



Left Hand View 100 H. P. Type "C" Special Heavy Duty Muncie Oil Engine Showing Regular Equipment for Belt Driving.

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CAMDEN			READING, PA.		

CRANE, Limited MONTREAL, TORONTO, VANCOUVER, WINNIPEG, LONDON, ENG., SYDNEY, N. S. W., QUEBEC, HALIFAX, OTTAWA, CALGARY.

We are manufacturers of many thousands of articles, including valves, pipe fittings and steam specialties, made of brass, iron, ferrosteel, cast steel and forged steel, in all sizes, for all pressures and all purposes; sanitation equipment for buildings of all kinds and sizes, and are distributors of pipe, heating and plumbing materials.

Products

Power plant specialties, fabricated pipe and bends ready for erection, pop safety valves, engine stop valves, steam traps, swivel expansion joints, steam separators, cast steel headers, pipe supports, exhaust relief valves, mine piping, pump columns, stop valves, check valves, water relief valves, flanges, bolts, gaskets, cocks for air lines, sediment traps, air safety valves, pressure regulators, expansion joints, screwed and flanged fittings, sanitary drainage fittings, long sweep water fittings and plumbing fixtures.

Regrinding Globe, Angle, Cross, Check Valves

No. 70 Globe.

These valves are made of Crane Special Brass. They are fitted with our improved non-heating malleable iron wheel and may be repacked when open and under pressure. The body is reinforced by a heavy union ring and when pressure is applied any tendency of the body to stretch is counteracted by this ring and the contact between the body and the ring becomes more intimate as the pressure increases. Tested to 250 pounds hydraulic pressure per square inch.

Extra Heavy Gate Valves, O. S. & Y.

These valves are made of Crane Ferrosteel with extra heavy hard metal seats which are screwed to shoulders in body, thereby insuring perfect joints. Seats can be removed at any time it may be necessary to renew them. The gate is made very stiff and is faced with hard metal. The guides in the gates are carefully finished so as to slide smoothly on ribs in the body, thus preventing any rattling when the valve is open or any uneven wear of faces. Stuffing box flange is of malleable iron with a brass follower, giving additional strength and durability at that point. These valves may be packed when open. Tested to 800 pounds hydraulic pressure per equare inch.

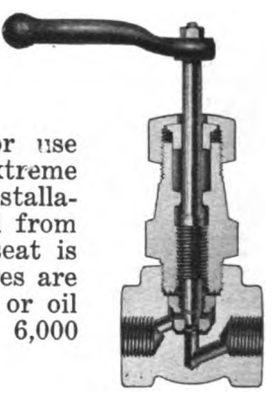
No. 9-E.

Mine Cocks

No. 313

For Compressed Air Lines are tested under air pressure and are suitable for 125 pounds air pressure and 175 pounds cold water working pressure. They are made all iron, or iron with brass plug, and have good steel springs which automatically take up wear.

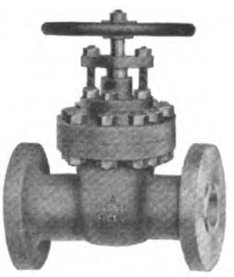
Forged Steel Globe and Angle Valves



No. 225-H.

Meet the demand for a thoroughly reliable valve for use with hydraulic presses and extreme high pressure air or gas installations. The body is machined from a solid steel forging. The seat is easily renewable. These valves are recommended for cold water or oil working pressures up to 6,000 pounds hydrostatic.

Extra Heavy Hydraulic Cast Steel Gate Valves



No. 205-D.

The bodies, bonnets, yokes and discs of these valves are made of Crane Cast Steel. In sizes above 2-inch the disc is faced with hard metal; size 2-inch has disc in solid hard metal. The construction of the seat and method of screwing it in the body, the strength and finish of the gate and stuffing box are similar to our No. 9-E valve. Also they may be packed while under pressure. These valves are recommended for cold water or oil working pressures up to 3,000 pounds hydrostatic, and are tested to 3,000 pounds hydraulic pressure.

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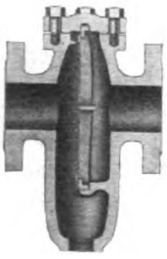
Crane-Erwood Automatic Double Acting Non-Return and Emergency Cut-Out Valve.

The principle duties of the Crane-Erwood Valve are boiler protection, header protection, automatic cut in, line protection. These valves are extra heavy, made of ferrosteel with hard metal seats and discs and are recommended for steam working pressures up to 250 pounds. The levers on the outside of the valve are in line with the discs and give a positive indication of their position and the operation of the valve at all times. The valve may be adjusted to close at any desired velocity. Adjustments are made from the outside while the valve is in operation.

No. 36-E.

Sediment Separators

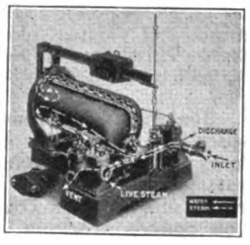


No. 989

For water working pressures up to 250 lbs. These sediment separators are constructed in a strong and substantial manner and will be found exceptionally valuable for use in connection with steam traps, pumps, injector and ejector suction pipes, feed water lines, etc. by preventing foreign substances from passing through and settling on valve seats and other places that should be kept entirely clear and free from such obstructions.

Cranetilt Steam Traps

Are designed as Non-Return, Boiler Feed, Lifting, Vacuum or Metering traps. They are especially adapted for use on return lines handling condensation under varying pressures, especially where the pressure will vary from a vacuum to steam pressure. The Cranetilt Three Valve trap gives excellent service on returns on apparatus that has a varying pressure while in service or a low initial starting pressure and a high terminal pressure. Buy steam traps by their discharge capacity—not by pipe sizes.



Three Valve Trap.

Flanged Pipe Joints

With Crane Cast Steel or Forged Steel Flanges are highly recommended for use in connection with pipe bends.

THREE STANDARD TYPES.

No. 281-D. Screwed Joint with Cast Steel Flange.

No. 295-E. Craneweld Joint with Forged Steel Flange.

No. 181-D. Cranelap Joint with Cast Steel Flange.

HYDRAULIC MALLEABLE FITTINGS

No. 260-H. No. 262-H. No. 264-H. No. 267-H.

Hydraulic Malleable Iron Screwed Fittings

The Crane line of malleable iron fittings includes all the necessary sizes and shapes for cold water or oil working pressures as follows:

1-inch and smaller,	2,000	pounds	hydrostatic.
1¼ to 2-inch,	1,500	"	"
2½ to 4-inch,	1,000	"	"
5 and 6-inch,	800	"	"
8-inch,	600	"	"
10 and 12-inch,	500	"	"

These fittings are tested to hydraulic pressures corresponding to the above working pressures.

Unions and Union Fittings

Made with **leak proof brass to iron seat** require no gaskets, may be taken apart readily and the seat is non-corrosive. Made of malleable iron for steam working pressures up to 250 pounds.

No. 519.

No. 591.

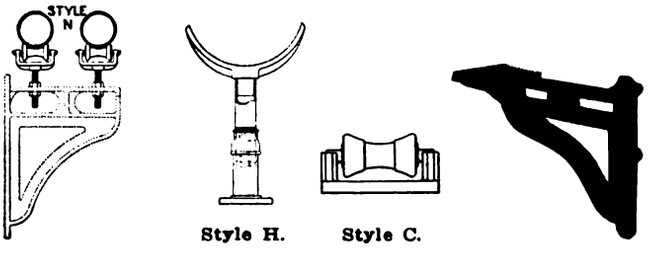
No. 596

Headers

We have exceptional facilities for making any required design of headers in cast iron, ferrosteel or cast steel, for all pressures and purposes.

Pipe Supports, Hangers and Brackets

Are suitable for pipe lines up to 30-inch.



Style H. Style C.

Our Catalogue No. 50, which describes our complete line, will be mailed upon request.

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JENKINS BROS.

Principal Stores and Offices

80 White Street
NEW YORK, N. Y.

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BOSTON, MASS.

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PHILADELPHIA, PA.

646 Washington Blvd.
CHICAGO, ILL.

Factories in Bridgeport, Conn., and Elizabeth, N. J.

JENKINS BROS., LIMITED
Canadian Works and Head Office: Montreal, Quebec, 103 St. Remi Street
London Office: 6 Great Queen Street, Kingsway, W. C. 2

MANUFACTURERS OF VALVES AND MECHANICAL RUBBER GOODS

Products

Jenkins Valves: Globe, Angle, Cross, Check, Hose, Y or Blow-off, and Safety Valves; Radiator Valves, in a variety of types; Air Valves, Fractional and Vacuum Valves, for heating systems; Extra Heavy Valves, specially designed for high pressures and severe conditions, in Globe, Angle, Cross, Check, Blow-off, Automatic Equalizing Stop and Check, and other patterns; Gate Valves, in Standard, Medium, and Extra Heavy patterns. Valves in Brass, Iron Body, and Cast Steel, for all pressures and purposes. Rapid-Action Valves; Jenkins Air Gun Marine Valves.

Back Pressure or Exhaust Valves; Steam Traps; Gage Cocks.

Mechanical Rubber Goods: Jenkins '96 and Jenarco and Oiltite Sheet Packing and Gaskets, Gasket Tubing, Pump Valves, Jenkins Composition Valve Discs, and the like, and Jenkins Compressed Asbestos Jointing.

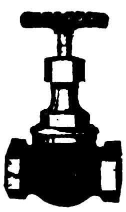
Fig. 106. Brass Globe Valve. Standard Pattern.

Valves for Mining Service

Jenkins Standard Pattern Brass Globe, Angle, and Cross Valves, sizes 1/8 to 3 inches, screwed or flanged, regularly furnished with Jenkins No. 119 Discs, suitable for 150 pounds steam pressure. When specified for cold water, valves are fitted with Jenkins No. 93 Discs, suitable for working water pressures up to 250 pounds. Other sizes in brass made from iron body patterns.

Fig. 142. Iron Body Globe Valve. Standard Pattern.

Jenkins Standard Pattern Iron Body Valves are heavier and stronger than the average iron body valves. They have renewable seat rings and Jenkins Discs; and are suitable for same working pressure as the standard pattern brass valves. Globe, and Angle Valves made in sizes 2 to 24 inches, inclusive; Cross Valves up to 8 inches. Flanges A. S. M. E. standard dimensions.

Jenkins Brass Horizontal, Angle, and Vertical Check Valves correspond to same standard as the Standard Pattern Globe and Angle Valves. Regularly furnished with Jenkins Disc of semi-hard composition which will soften slightly under the action of hot water as required for boiler feed lines. When specified for cold water, air, or gas, a softer and more flexible rubber disc is supplied, usually Jenkins No. 93 composition. Suitable for 150 pounds working pressure. Sizes 1/8 to 3 inches, screwed or flanged.

Fig. 118. Brass Angle Check Valve.

Fig. 352. Brass Swing Check Valve.

Jenkins Brass Swing Check Valves, Standard Pattern, are made with globe shaped bodies adapted for either horizontal or vertical installation; have renewable disc feature same as the horizontal pattern; and are suitable for same working pressures. Sizes 1/4 to 3 inches, screwed or flanged.

Fig. 294. Iron Body Swing Check Valve.

Jenkins Iron Body Horizontal, Angle, Vertical, and Swing Check Valves made in sizes 2 to 10 inches; suitable for working pressures up to 150 pounds.

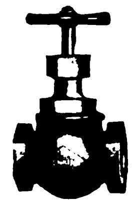
Fig. 75. All Iron Globe Valve.

Jenkins All Iron Valves are recommended for service in places where, on account of possible corrosion, no brass mountings of any kind can be employed. The all iron bodies and mountings and renewable discs of cast iron or of special Jenkins composition, make them suitable for handling solutions of cyanide, saltpetre, caustic potash, and the like. It is advisable when ordering to specify conditions of service, so that disc of proper composition will be furnished. All Iron Globe and Angle Valves, with screwed hub, as Fig. 75, sizes 1/2 to 2 inches; with yoke, as Fig. 142, sizes 2 1/2 inches and up; horizontal, angle and vertical check valves, 1/2 inch and up. All Iron Gate Valves with solid iron, double faced wedges sizes 1/2 inch and up.

Jenkins Y or Blow-off Valves, Standard Pattern, besides their extensive use for blow-off service, are particularly desirable for handling muddy or gritty water. Have renewable seat rings and Jenkins Discs; suitable for 150 pounds working steam pressure, or 250 pounds working water pressure. Brass valves, sizes 3/8 to 3 inches; iron body valves, 2 to 8 inches, inclusive. Extra Heavy Patterns in both brass and iron body for working steam pressures of 250 pounds or 400 pounds water fitted with Jenkins Steam Metal Discs or Composition Discs as service dictates.

Fig. 124. Brass Y or Blow-off Valve. Standard Pattern.

Selclo Valves

Fig. 357. Selclo Valve.

Are specially designed for rough usage. They are particularly valuable in places where different people, often careless or hurried, have occasion to operate the valve, and where the service is exceptionally severe. Turning hand wheel to the left pushes Disc Holder off the seat and opens the valve. Turning hand wheel to the right releases spindle from the Disc Holder, and spring forces Disc Holder to the seat, and the pressure holds valve closed. The strong armed man cannot crush the disc. Made in sizes 3/4 to 2 inches.

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Jenkins Gate Valves, all of the solid wedge double face type, are made in three distinct patterns, both inside screw, and outside screw and yoke. Standard Pattern, suitable for 125 pounds steam or 175 pounds water pressure, sizes, brass ¼ to 3 inches, iron body 2 to 30 inches, inclusive. Flanges are A. S. M. E. Standard Dimensions.

Fig. 370. Brass Gate Valve, Standard Pattern.

Medium Pressure, specially designed for steam or hot and cold water lines where high grade installation is required; but where the pressure does not warrant the use of the more expensive extra heavy pattern, are guaranteed for 175 pounds steam and 250 pounds water. Sizes: Brass, ¼ to 3 inches; iron body 2 to 18 inches, inclusive, with

Fig. 327 Iron Body Gate Valve, Hub Ends.

Fig. 325. Iron Body Gate Valve, Inside Screw.

Fig. 331. Iron Body Gate Valve, with Yoke.

or without by-pass. Flanges A. S. M. E. Extra Heavy Standard Dimensions.

Fig. 128. Extra Heavy Brass Globe Valve.

For high pressure steam and hydraulic service valves are made for extra heavy patterns in brass, iron body, and cast steel. Sizes: Brass ½ to 3 inches; iron body and cast steel 1½ to 24 inches.

The Extra Heavy Pattern Brass Globe, Angle, Cross and Check Valves are suitable for working steam pressures up to and including 300 pounds; or for water and air pressures up to 500 pounds. Sizes ¼ to 3 inches.

Fig. 164-c. Iron Body Angle Valve, Extra Heavy with By-Pass.

Extra Heavy Iron Body Valves are suitable for working pressures up to 250 pounds steam and 400 pounds water. Globe, Angle, and Cross Valves made in sizes 2 to 12 inches; valves from 5 inches up can be supplied with by-passes which are cast integral with the body. Horizontal and Vertical Check Valves 2 to 6 inches; Swing Check Valves, 2 to 8 inches; Y Valves, 2 to 3 inches. Automatic Equalizing Stop and Check Valves designed to equalize the pressure in a battery of boilers, preventing one boiler from working at a lower pressure than another, insure against accidents as they automatically shut off the flow of steam from header to boiler in event of a broken tube or connection. Sizes 4 to 8 inches. Gate Valve, with inside screw, or outside screw and yoke, sizes 1½ to 24 inches; all flanges A. S. M. E. Extra Heavy Dimensions.

Fig. 293. Automatic Equalizing Stop and Check Valve.

Jenkins Cast Steel Valves are made in Globe, Angle, Gate, and Check patterns, which experience

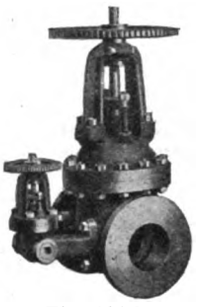


Fig. 204-b. Iron Body Valve, Extra Heavy O. S. & Y.

Fig. 203. Iron Body Gate Valve, Extra Heavy Inside Screw

has shown are perfectly adapted for the severe conditions incident to high pressure super-heated steam service. The valves are suitable for working steam pressures up to 350 pounds, and total temperature of 800 degrees F. Furnished in practically the same sizes as the Extra Heavy Iron Body Valves.

Jenkins Compressed Asbestos Jointing is the material we recommend for superheated steam joints. It is compounded to resist heat to the utmost degree. Made in sheets 40"x120", 1/64, 1/32, 1/16, 3/32 and ⅛" thick.

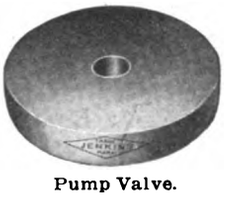
Mechanical Rubber Goods

In this line we are offering engineering requisites which are the result of years of progressive effort. We are the original manufacturers of rubber composition discs for valves and unvulcanized sheet packing.

Jenkins '96 is the name of our high grade unvulcanized or self-vulcanizing packing, furnished in sheets or gaskets, and unsurpassed for all kinds of saturated steam joints. **Jenarco** is a vulcanized red sheeting. It is very tough and pliable, equally suitable for steam, hot or cold water, and other joints.

Jenarco Sheet Packing.

Jenkins Pump Valves are made from various compounds. There are pump valves of hard composition, particularly adapted for hot water, as with boiler feed pumps; for oils, acids, and other destructive fluids; semi-hard valves for high pressure cold water service as in mines; medium soft for cold water; very soft and flexible for low pressure cold water and air. When ordering, state the kind of service in which the valves are to be used, the fluid handled, pressure or head pump is working against, and in all cases give diameter, thickness, and size of hole.



Pump Valve.

For convenience it is suggested that figure numbers also be specified.

Genuine Jenkins Valves are stamped on the body with the "Jenkins Diamond Mark" and signature. All goods so marked are guaranteed to be perfect in workmanship, and suitable and efficient in the service for which they are recommended.

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THE KELLY & JONES COMPANY

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BUFFALO—572 Ellicott Square

Manufacturers of

Power Plant Equipment, Brass, Iron and Steel Valves, Fittings, Cocks, Etc.

Products

Malleable Iron Fittings; Cast Iron Fittings, screwed and flanged; Cast Steel Fittings; Wrought Iron Pipe and Nipples; Brass Fittings; Brass Valves and Cocks; Iron Body Valves and Cocks, screwed and flanged; Cast Steel Valves; Engine and Boiler Trimmings; Expansion Joints; Specialties, etc., for Steam, Gas, Water, Air and Oil.

Our new 1922 Catalog "S" which describes and illustrates our complete line will be mailed upon request.

Improved Re-new-disc Valves

Made in sizes ¼" to 3" and are furnished with Malleable Iron Non-heating hand-wheels, Stuffing Nuts and Bonnet Rings. Also furnished with a renewable composition disc and a specially constructed disc holder which permits of quickly removing the disc for renewal purposes. Recommended for 150 pounds steam working pressure and will give long and dependable service.

Globe Valve
Fig. 227

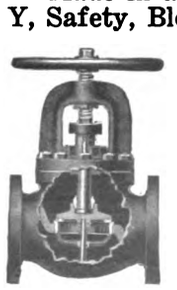
Angle Valve
Fig. 227-A

Hor. Check Valve
Fig. 227-B

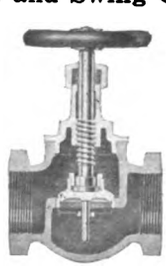
Iron Body Valves

Made in all sizes from 2" to 16", screwed or flanged, with or without yoke for 125, 175 or 250 pounds working pressure.

Made in all styles, Globe, Angle, Cross, Check, Y, Safety, Blow-off and Swing Check, and are correctly designed with strength added where the greatest strain is caused.



Extra Heavy Globe, Flanged with Yoke



Standard Globe, Inside Screw

Medium Angle, Screwed with Yoke

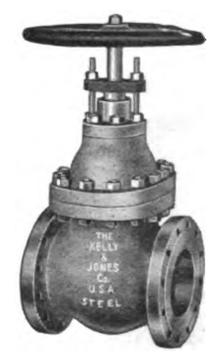
Can also be furnished in All Iron, Steel or Bronze for all purposes and pressures.

Cast Steel Valves

Our Steel Gate Valves can be furnished in all sizes from 1¼" to 24" and are recommended for 250 to 350 pounds superheated steam pressure. The strength, elasticity, elongation, reduction and bending of our steel valves are in accordance with the strictest specifications. We also make a complete line of Brass and Iron Body Gate Valves for all pressures and purposes.

Outside Screw and Yoke, Wedge Gate

With By-pass

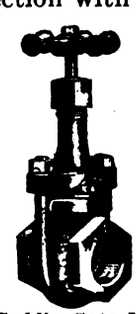


Non-rising Stem

Standard Saddle Type Straightway Valves

Can be furnished either black or red japanned, as desired. This saddle style is a very durable and compact valve, and economical, owing to the simplicity of construction. The steel saddle around body of valve holds bonnet securely in place, and can easily be removed, permitting of access to interior. Opens to left and has rising spindle.

For 125 lbs. working pressure. All-iron or iron body, brass mounted. When furnished iron body, brass mounted, all parts are iron, except disc, stuffing nut and stem, which are high quality brass. All-iron style recommended very highly, for use in connection with cyanide, creosote, etc.



Saddle Gate Valve

Sectional View

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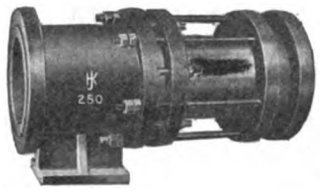
Expansion Joints

We make a complete line of Expansion Joints, all sizes, screwed or flanged for all pressures and purposes. The Extra Heavy Iron Body pattern is recommended for 250 pounds pressure and the Extra Heavy Cast Steel pattern for 350 pounds superheated steam pressure and can be furnished with or without anchor base.



Expansion Joint with Anchor Base

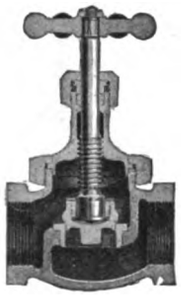
Regrinding "Excelsior" High Pressure Brass Valves

Regrinding "Excelsior" valves are designed to meet the demand for valves suitable for working pressures from 200 to 300 lbs. of live or superheated steam, and are extensively used in modern steam plant construction. The stuffing boxes can be packed while under pressure and valve reground while in position, without disturbing the pipe connections, by making slight adjustments and rotating the stem backward and forward.

Made of the highest grade metal and furnished in globe, angle, cross or check patterns. The outside screw and yoke pattern is recommended for superheated steam. The nickel seat style is so constructed as to permit of easy removal of the seat for renewal purposes.

Globe

Cross



Nickel Seat

Brass, Straightway Valves, Solid Wedge, Gate

These valves are of the latest improved design, well proportioned and of good weight. They are made special pattern for pressures up to 100 lbs.; standard for 125 lbs.; heavy for 150 lbs.; medium for 175 and 200 lbs.; extra heavy for 250 lbs.; and extra heavy hydraulic for 1000 lbs.

The guides on the discs and the ribs in the bodies of these valves are fitted accurately, insuring a true and easy movement, thus preventing wear of the faces. They also keep the discs from touching the seats in the bodies except at the closing point.

Standard

Outside Screw and Yoke

Extra Heavy

Solid Wedge

Jenkins Type, Standard Kelly & Jones Brass Valves

Made of high grade steam metal, correctly designed and carefully machined. Of standard weight and durable construction.

The Y or blow-off brass valve has a full opening very nearly in direct line with the pipe, which practically eliminates resistance to the free flow of steam or liquids. It is specially adapted for handling thick fluids in sugar refineries, paper mills, chemical works, etc.

Globe

Y

Angle

Swing Check

Malleable Iron Unions

Our Malleable Iron Unions can be furnished in all sizes from ⅛″ to 4″ for all pressures and purposes.

The "Nip" Union is one of the simplest unions made, having only 3 parts—Nut, Swivel and Thread End. The brass to iron seat insures a tight joint and the brass to iron thread connection permits the union to be reconnected any number of times without injury. The straight bore or uniform diameter of the waterway insures a free passage—no pockets to collect sediment and choke up line.

The "Norustocta" Union is a heavy, well made union, entirely copper covered, suitable for 250 pounds working pressure and absolutely rustless.

"Norustocta" Union
All parts completely covered with copper electrically applied.

Nip Union
No inserted parts. The ring and bottom made of malleable iron, thread end of brass.

Brass Seat Union
Round or octagon ends, iron or brass nut.

Flanged Fittings

We make a complete line of Flanged Fittings, all sizes, straight or reducing, in Cast Iron, Steel or Brass for all pressures and purposes. Only the best grade of raw material is used in the manufacture of our line of Flanged Fittings.

The machine work is carefully executed and dimensions are in accordance with the latest American Standard, adopted January 1, 1915.

Elbow

Tee

Cross

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NELSON VALVE COMPANY

Main Office and Works
Chestnut Hill, PHILADELPHIA, PA.

Branches

ATLANTA, BALTIMORE, BOSTON, BUFFALO, CLEVELAND, CHICAGO, DETROIT, LONDON, ENG., LOS ANGELES, MINNEAPOLIS, NEW YORK, PITTSBURGH, SAN FRANCISCO, SCRANTON, SEATTLE, SYRACUSE

Manufacturers of

Valves and Expansion Joints in Bronze, Iron, Steel and Monel

Products

Expansion Joints; Valves—Anti-acid, Back Pressure, Blow-off, By-pass, Check, Engine Stop, Marine, Non-return (emergency), Oil, Relief, Safety, Stop; Valves and Fittings.

The Nelson line embraces every type of valve employed in the highest class power and industrial installations, including specially constructed valves for superheated steam and for acids, alkalies, oils and other special service. 27 years' experience insures to Nelson Valve users the highest possible degree of service and construction.

Bronze Valves

NELSON bronze valves are made in gate, globe, angle, cross, swing check, cup check, quick opening, blow-off and marine types for all working pressures up to 2000 pounds. Special acid resisting bronze valves and nickel bronze valves with bronze or monel mountings are one of our specialties.

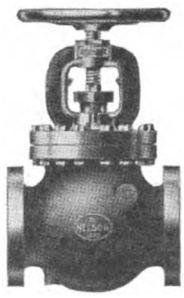
Bronze Check

The superior design and excellent workmanship with the resulting increase in service has caused thousands of plants throughout the country to specify and use exclusively the NELSON brass line.

Send for Bulletin MF 5 describing the globe valve lines, Bulletin MF 4 showing the gate valve lines, or Bulletin MF 6 covering an unusually fine group of bronze valves for superheated steam.

Iron and Semi-Steel Valves

In the NELSON line all the types generally known as iron body are regularly made in our superior grade of semi-steel which increases the tensile strength and lasting qualities of the casting without increasing the cost. NELSON valves have long had the reputation of being of better design and workmanship than the average commercial valves.



Semi-Steel Globe

NELSON semi-steel valves are made in gate, globe, angle, cross, stop check, vertical check, swing check, cushioned check, non-return stop and check and blow-off types with bronze, monel composition or steel mountings. We are prepared to furnish quickly all sizes of valves for pressures up to 300 pounds steam. We have patterns for promptly furnishing gate, globe, angle and check valves for hydraulic or oil lines with pressures up to 5000 pounds.

All iron gate valves for chemical lines are carried in stock and we are prepared to furnish all iron valves or iron valves with steel mountings or monel mountings for various pressures.

The NELSON double disc construction is very simple and yet positive in action. It consists of two discs and central wedge, only three parts. The discs move freely and are prevented from scraping the seats by guides on each side. Under the spreading action of the wedge the discs adjust themselves to the seats and insure a light valve. This construction can be had in brass, iron and steel valves.

Monel Valves

Monel metal is now generally accepted as the best metal for mountings of valves for superheated steam and high temperatures. During the past few years very extensive tests have been made to determine the value of this metal for resisting the corrosive action of acids and other destructive chemicals. These tests proved that monel is especially desirable for—

Monel Globe Valve

Aluminum Sulphate	Potassium Hydroxide
Ammonia	Salicylic Acid
Benzoic Acid	Sodium Hydroxide
Calcium Chloride	Sodium Sulphate
Calcium Sulphate	Stearic Acid
Carbolic Acid	Sulphuric Acid
Hydrochloric Acid	Tannic Acid
Hydrocyanic Acid	Tartaric Acid
Nitric Acid	Water Salt
Oleic Acid	Metallic Mercury
	Palmitic Acid

Realizing the great value that all monel valves would be to the chemical field the NELSON VALVE CO. made extensive experiments to develop a method of making small castings of this metal that would be suitable for high grade valves. As a result of this experiment we now offer gate, globe, angle or check valves made entirely of genuine INCO monel. We solicit inquiries from engineers who have trouble with their valves and desire to know if all monel valves are suitable for their conditions. In writing send full details.

Steel Gate

Steel Valves

NELSON steel valves are made with bronze or monel mountings in gate, globe, angle, check or non-return types for all pressures. We make a specialty of steel valves for high pressures and superheated steam.

Expansion Joints

NELSON expansion joints are made is brass, iron, semi-steel, steel and monel for all working pressures.

Special Valves

The NELSON plant is well equipped to produce valves built to unusual specifications for special service.

Complete catalogue or bulletin sent on request.

Specify "NELSON"—It Pays

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GREENE, TWEED & CO.

109 Duane Street, New York, N. Y.

Manufacturers of

HIGH GRADE PACKINGS

These packings are especially adapted to MINING SERVICE, as they are designed to give long service.

They contain NO RUBBER, and therefore are not affected by climatic conditions. As its materials are not affected by age "Palmetto" packing is always the same high grade quality, no matter what the climate is, or how long it remains in stock after being manufactured.

For Steam and Compressed Air

"PALMETTO"

gives longer service than other packings, even under the high temperature of superheated steam and compressed air, because it is made entirely of the highest grade asbestos, having such length of fibre and tensile strength as to make it unnecessary to use any cotton, as is imperative when cheap short fibre asbestos is used, the life of which is short, as the heat burns the cotton and releases the short asbestos fibre, causing the stuffing box to quickly leak.

Lubrication—"Palmetto" has a special graphite grease lubricant forced hot into each single strand before braiding, and not dipped into the lubricant after braiding, as most packings are.

"Palmetto' does not harden in service.

"Palmetto" can be depended upon to give long, satisfactory service.

For Hydraulic Pressures

SQUARE
PALCO
PLAITED PACKING

designed especially to give long, satisfactory service under hydraulic and low steam pressures containing considerable condensation and no excessive temperature.

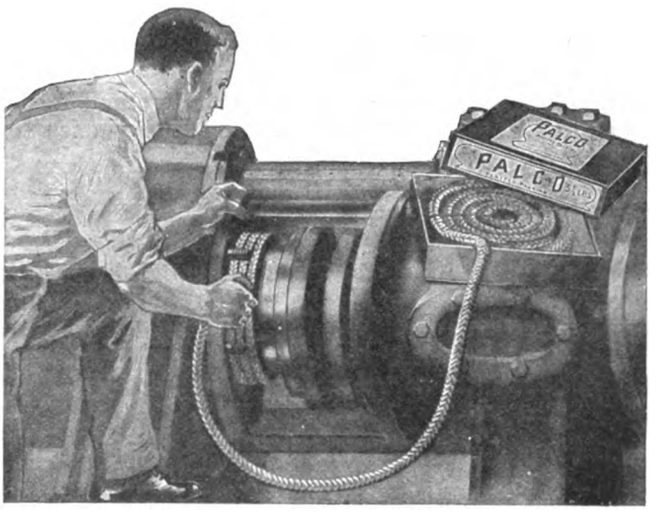
"Palco" packing is made of high tensile strength cotton, lubricated with a graphite grease lubricant in each single strand before plaiting. It is, therefore, superior to square flax packings.

"Palco" does not swell and bind and does not cause the pump to short stroke.

"Palco" is practically a frictionless packing.

Sizes ¼" to 2".

Put up in 5-lb. dust-proof boxes.



PROOF OF QUALITY

Let Us Send You, Without Charge, Working Samples of These Packings, Enabling You to Make a Thorough Test

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THE B. F. GOODRICH RUBBER CO.

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San Francisco, Cal.
Seattle, Wash.

THE INTERNATIONAL B. F. GOODRICH CORP.
London Capetown Singapore

Steam Hose and Packings

Mechanical Rubber Goods of Every Description

For Transmission Belts, see pages 206 and 207; for Conveyor and Elevator Belts, see pages 662 to 666; for Air Drill Hose, see page 303; for Fire Protection and Water Hose and Couplings, see pages 794 and 795.

Products

Steam Hose; Packing — Sheet, Hydraulic and Piston.

Steam Hose

It is more difficult for the average buyer to select the proper grade of steam hose than almost any other item of mechanical rubber goods. The fact that temperature increases with increase of steam pressure makes it necessary to increase the quality of the hose as well as the thickness of the wall in order to meet higher pressures. This is a fact often overlooked by buyers who think that all that is needed to resist high pressure is to increase the number of plies in the hose.

We make steam hose for use under all conditions of temperature and pressure practicable for rubber hose, and you will find in the following description of our different brands the pressures for which each is recommended.

Superheat Brand

Superheat Brand is recommended for working pressures over 125 pounds. Its tube is so compounded as to resist to the highest degree the extreme temperatures encountered in high pressure steam work and its fabric is sturdy enough to hold these pressures. It is the last word in high pressure hose.

Goodrich Brand

For pressures up to 125 pounds, Goodrich Brand has for years been the world's standard, and it holds service records unmatched by any quality on the market today. The fabric is the same as that used in Superheat Brand. The tube is of exceptional quality and capable of resisting almost indefinitely temperatures for which it is recommended. You will make no mistake in standardizing on Goodrich.

Falcon Brand

For low pressure work up to 25 or 30 pounds, Falcon Brand will prove reliable, economical and efficient. Within its limits, it will give satisfaction and earn its cost against competitors' hose.

Packings

Goodrich makes packings for practically every mining need. The more important of these are listed on the following pages and service recommendations are given.

To most users, packing seems a complex subject, yet, properly used, a few constructions and qualities will effectually pack every joint. It is our belief that most packing problems can be solved with Goodrich Packings.

Sheet Packing

Sheet Packings are of three classes—(1) Steam, (2) Water, (3) Special Service, as oil, ammonia, etc. Each requires different compositions and must be treated as a separate problem.

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Steam Hose and Packings

Steam

Akron Red Sheet Packing—For pressures up to 125 pounds, red sheet packing has always been considered standard and has performed very favorably. Akron is our recommendation for this service—it is an excellent heat resisting compound, has a low gravity and is not only low in first price but in ultimate cost as well.

Superheat Packing—Resisting the pressures and temperatures of super-heated steam is another matter and one which has only recently been solved. No rubber compound can successfully withstand such temperatures and pressures and the search for a satisfactory material has covered nearly every available metallic and non-metallic substance. Asbestos has always been recognized as ideal, but the problem has been to incorporate it into a sheet that would successfully meet pressure conditions. Goodrich "Superheat" does this. It is long fibre asbestos with a minimum amount of specially compounded binder to hold the fibres together and make a strong, flexible sheet. The service it has given over a period of years and our constantly growing sales demonstrate its fitness. We recommend No. 10 gray—a sheet of highest quality, unusual tensile strength and perfect heat resisting qualities. No. 33 red is a dandy packing for those who appreciate quality at a low price. It is only slightly lower in quality than No. 10 and will easily earn its cost against competitive packing.

"Superheat" Packing can be furnished graphited on one or both sides, if desired at the same price as the plain.

Water

For cold water, most people use "Akron" Red Sheet. It is perfect. For those who prefer the cloth inserted type, we recommend Grade No. 50, cloth inserted or with cloth on one or both sides.

Special Service

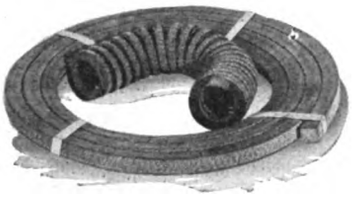
For oil, "Summit" is unmatched. It is the result of years of experiment and represents the ultimate in an oil resisting sheet—equally good at all temperatures.

"Superheat" is our suggestion for ammonia lines. Nothing else has yet been found that resists the drying action of ammonia gas as well.

For service on acid lines, etc., consult us. We have special grades that will do the work, but, as every problem is different, space does not permit of our listing them.

Hydraulic Packing

For packing the water end of reciprocating pumps, B. F. G. Hydraulic Packing is our recommendation. Its reputation over a period of years in the oil fields where hydraulic packing meets the most severe service has been unmatched by any other on the market. It is higher in first cost, but cheaper in proportion to service rendered.



Piston Packing

It is in this field that the greatest variety of packing is found. We do not pretend to be packing specialists, offering a different grade for every conceivable service condition, but we do wish to bring to your attention a construction which we believe will effectually pack the majority of piston rod stuffing boxes and eliminate the necessity of carrying in stock a wide range of constructions. This packing is "Pinnacle" Diagonal Fabric—sometimes known as Cross Expansion Packing. Pinnacle adjusts itself to uneven, scored, and bent rods with perfect ease, stays tight and lasts indefinitely. For all low pressure and medium pressure work, you will find it unexcelled.

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SECTION IV

Power Transmission

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Cleveland Worm & Gear Co.
Dodge Sales & Engineering Co.
Falk Corporation, The
Fawcus Machine Co.
Foote Bros. Gear & Machine Co.
Ganschow, William Company
Goodrich, B. F. Rubber Co., The
Jones, W. A. Foundry & Machine Co.
Link-Belt Company
Medart Company, The
Morse Chain Co.
Niles-Bement-Pond Co.
Nuttall, R. D. Company
Poole Engineering & Machine Co., The
Smith & Serrell
Tool Steel Gear & Pinion Co., The

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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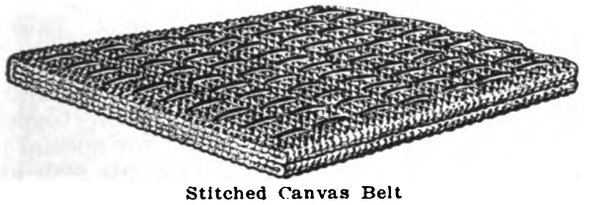
FABRIC BELTS*

Fabric belts can be divided into three general classes. (a) Solid woven cotton, camel's hair, or other fibrous material (usually impregnated with a waterproofing compound). (b) Stitched canvas. (c) Rubber or balata, which are composed of several plies of cotton duck cemented or vulcanized together with the tropical gums, giving them their name.

There are numerous plies, weights and forms of weaving and stitching. Several varieties of American and imported cotton fibres are also used in the fabric base.

Woven and Stitched Belts

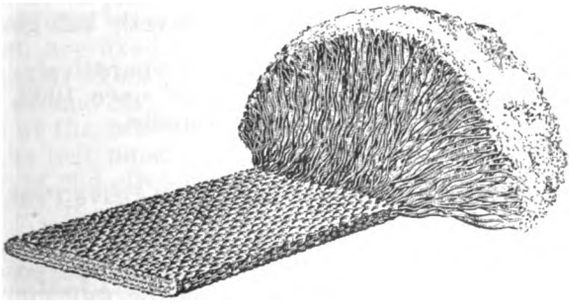
Cotton is the material in general use for making woven and stitched belts. There are two general methods used in the making. The more common is the combination of several layers or plies of cotton duck. These plies are sewed or stitched in various patterns to increase the tensile strength and prevent excessive stretching of the material.



Stitched Canvas Belt

Various weights of duck are used, and in purchasing it is advisable to know exactly the weight of the material, the kind of cotton used and the methods of weaving. Even then the specifications may be so confusing that the best method is to place dependence on the recommendations of a manufacturer whose name and product are well known and of proper worth.

The solid woven belt is produced from a special yarn of cotton or other fiber woven into solid belt in somewhat the same manner as a lamp wick. The different makes of this type vary considerably in the weave and method of manufacture, but all possess a homogeneous body produced in widths and weights proportioned to the service required.



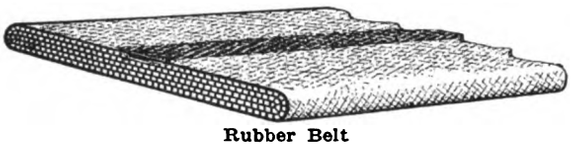
Solid Woven Belt

*From Catalog of Flexible Steel Lacing Co., Chicago, Ill.

In both methods of manufacture the material is specially treated to withstand friction, dirt, atmospheric conditions, etc.

Rubber Belts

The construction of rubber belting consists of a backbone of cotton duck which is specially treated with rubber compound.



Rubber Belt

Crude rubber is obtained from the Hevea tree, which grows in nearly all tropical countries. It yields a milk-like fluid that thickens and becomes dark upon contact with the air. The rubber gatherer prepares the fluid for market by pouring it over a stick and turning it around in the thick yellow smoke of burning palm nuts. This smoking process imparts a tough, tenacious quality to the rubber. As each layer hardens more fluid is added until the ball is about twelve inches in diameter. The balls are then split for shipment.

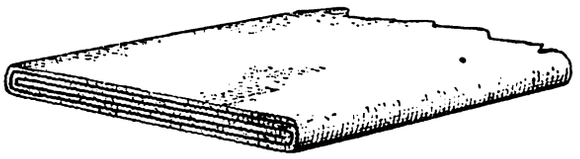
Methods of preparing the rubber compound and applying it to the duck base differ in method but the principle is generally the same.

The duck is inspected and tested for imperfections. All moisture is removed. The compound is applied and forced into the plies by pressure. The whole is then vulcanized under terrific pressure which removes all superfluous stretch and unites the rubber and duck into one inseparable body.

Rubber belting is made in both red and gray colors.

Balata Belts

Balata belting has a canvas base or backbone similar to rubber belting. Balata is a vegetable gum that comes from the milk of a tree which grows in the Guianas.



Balata Belt

The process of manufacture differs somewhat from rubber belting. The fabric is thoroughly impregnated with Balata gum. The outer surface is finished off with a thin coating to give it a finished

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appearance. The whole is welded into solidity under pressure, although it is not vulcanized in the manner of rubber belting. This type of belting is satisfactory for general transmission service, other than where extreme heat prevails.

Rope Drives

Rope drives are more extensively used in Europe than in this country. The English system employs a single grooved drive pulley from which several parallel rope belts distribute power to several places. The English multiple rope method employs several parallel ropes over grooved pulleys for main driving power.

In contrast to the English multiple system is the American single rope belt. The rope is carried around the grooved pulleys as many times as necessary to gain the desired power. From the last groove in the driven pulley the rope is carried by an idler back to the starting groove in the driving pulley. In this way a continuous single rope drive is secured.

Among the advantages offered by rope belts is their economical installation and their ability to transmit power to a considerable distance.

Leather Belting

This type of belting is efficient, although expensive, and in standard grades gives long service. It is adapted to dry work under protection from the weather. The wearing qualities and slight attention required have made its use general under the conditions to which it is suited.

The best leather belts are selected from hides of four-year-old steers killed in the fall. The hides of animals over this age have lost some degree of their flexibility or if younger have not gained their greatest strength. For the best wide belts only a center back strip 30 inches wide and 50 inches long is used. As the distance from the spine increases, the stretching quality of the belting varies. For narrow belts strips cut equally distant from the spine on either side and spliced together are used, this making a belt that stretches evenly and runs straight over the pulleys.

Leather Belt

Oak tanned leather is the type most used in general work. It is light in color and hard and firm in texture.

Ordinary oak tanned belting is not at its best when exposed to certain conditions, such as the action of water, steam, oil, heat, chemical fumes, etc. For work under these conditions specially finished belts should be used.

Chrome leather belting is one of the best for special purposes. Chrome tanning imparts qualities to the leather which enables it to be used under the most severe conditions, such as excessive heat, steam, etc.

Single leather belting consists of one thickness. Double thickness is composed of two thicknesses of leather, the strips being cemented together. Heavier belts are sometimes made for special purposes, but can be used to advantage only over extra large pulleys.

Comparison of Belt, Chain, Gear and Direct Connected Drive*

It is our personal opinion that the size of the drive and its location, as well as the type of the equipment used, very frequently determines the kind of drive that is best adapted for the particular installation. In some cases it is absolutely necessary to use a belt or chain drive, and in other cases a gear or direct connected drive would work out satisfactorily.

Development of Methods of Transmitting Motion

The first means employed to transmit motion from one shaft to another was by plain friction wheels, but no matter how good the construction and ideal the conditions slippage would occur. The next step was to connect the two wheels together by a belt. This in many cases was more satisfactory, but in heavy drives and sudden loads more or less slippage still occurred, especially on large reductions in speed. When the wheel of the pulley is large and the driving pulley is small the belt will have little contact on the small pulley, hence the reduced power.

To eliminate slippage, strips were fastened on the friction wheels, then crudely shaped teeth or cogs, until now we have the perfectly cut gear.

The silent chain drive is comparatively new, having been in use commercially since 1902. Its use has been increased very rapidly.

Requirements to Be Met in Solving Drive Problems

To solve drive problems, many new methods have been devised and used for the purpose of meeting as many as possible of the following requirements: (1) high efficiency, (2) low first cost, (3) low maintenance cost, (4) low rate of deprecia-

*Extracts from committee report by J. B. Penman, N. A. Johnson and T. W. Blake presented at annual meeting of West Virginia-Kentucky Association, September, 1921.

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tion, (5) simplicity in design, (6) noiselessness, (7) a certain amount of flexibility and elasticity capable of absorbing shocks and vibrations, (8) high ratio of transmission, (9) freedom of selecting the relative location of shaft.

Inasmuch as our subject is confined more particularly to mine pumps and fans and we are of the opinion that the fan is the more important of the two, we shall dwell mostly on that machine.

Where there is ample room and more than 30 H. P. is to be transmitted, it is our opinion that a belt drive is most practical. The use of electrically driven fans is coming into use more each day, and many of the drives are connected up to squirrel cage motors, which must be started on two steps. In starting a fan with a squirrel cage motor, the characteristic curve or power consumption shows five or six times that required after the fan has been brought to full speed. Such an effort with chain or gear drive would be very trying to the equipment, but with a belt drive it is a different proposition, as during the period the fan is gaining momentum there is a tendency for the belt to slip on the pulley. This of course relieves the strain on the fan, but with a chain or gear drive this relief is impossible.†

Chain Drive Suitable for Small Disc Type Fans

With small fans, such as the common disc type, requiring from 5 to 30 H. P., we see no reason why a chain drive could not be used to advantage, but if the chain is used on a disc type fan it should be of sufficient centers to place the motor out of the direct path of the air. The starting duty of a disc fan is much less severe than that of a centrifugal, therefore the squirrel cage motor and chain drive is very practical.

In the case of a fan installed where there is not sufficient room for the regular standard belt drive, the chain drive works very well; however, there can be used an idler with a short belt drive, or something on the order of the Lenox drive, a device scientifically applied to a belt drive for the purpose of giving a large arc of contact between the belt and pulley. It is provided with means for automatically adding or subtracting from the arc as the belt stretches or contracts, in proportion to the power transmitted. This device consists of a roller supported in a movable frame held by weights or counter weights against the slack side of the belt close to its face and parallel with the axis of the smaller pulley of the drive. The frame is mounted on a pivoted shaft, resting in bearings which are fixed to a suitably designed, supported pedestal. The roller has two distinct movements, one around its own axis, the other parallel to the axis of the smaller pulley of the drive. The length of the belt must be such as to permit the greater part of the circumference of the pulley to be covered by it.

We appreciate the fact that a direct connected fan outfit is very nice; it looks practical and sounds practical, but we must bear in mind that we are limited to a certain speed for the most economical duty; in other words, it is bad practice to turn a fan at a very high rim speed to simply pull the air through its inlets, and it is this fundamental principle which makes a direct connected centrifugal fan almost impractical. You cannot get the speed of the motor low enough for economical operation.

It is true some disc fans, and even centrifugal fans up to four or five feet in diameter, can be direct connected to motors, but when a fan must handle 100,000 cubic feet or over the cost of the motor is almost prohibitive for direct connection. You may, however, install turbo gear reduction between the fan and motor, that is, one of the turbo gear direct to the fan shaft and the other shaft of turbo gear in direct connection with the motor shaft. A probable reduction of 3 to 1, 4 to 1, or even as high as 6 to 1, can be made with turbo gears, but this method has its drawbacks as well as the direct connected outfit; you are simply tied up to one speed, unless some type of variable speed motor is used.

We have not touched on fans driven from engines, due to the fact that very few are being installed at the present time.

Pumps

Pumps of the reciprocating type are nearly always gear driven, and owing to the fact that variable speed is not an important feature for this type of equipment, it is our opinion that this type of drive would be hard to improve upon. The centrifugal pump, on the other hand, can hardly be bettered as a direct connected outfit. The direct connected drive is very good, especially where the speed of the pump is rather high.

We believe that the gear driven pump, especially the reciprocating type, has a distinct advantage over chain or belt drive, because you cannot use a belt drive in wet or dirty places, whereas gears can be used in pairs or can be designed to transmit any power required at any distance through shafting, in water, acid and grit, at any angle of shafting, internal as well as external drive, and can be relied upon to give a steady and even motion.‡

The chain drive has a field of its own, and is used very little in the mines for pumps, but it has its advantage in long distance drive, where gear train would be too expensive and where the power to be transmitted is not too great nor the speed too high. It is rather noisy and tends to give a jerky motion, especially as the chain begins to elongate and wear. The silent chain drive tends to overcome considerable of these objections, but it has its limit also. A gear driven pump of the reciprocating type is strongest and the most adaptable.

†Editor's Note—At those mines where the fan is seldom stopped this objection would apply with decreased force.

‡Editor's Note—An advantage of the belt or chain drive not mentioned in the report is its comparative noiselessness. This applies particularly to pumps located near the shaft bottom, foreman's office, inside partings or other places where workmen are employed.

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Helpful Hints on Belts

A belt should never be overloaded.

Install belts sufficiently tight in the first place to avoid early taking up. If a belt has stretched take it up at once, and do not wait until it has become damaged through slippage. Bear in mind also that too tight a belt increases friction at the bearings and wastes power.

Keep oil away from all belts. It has a detrimental effect upon them and reduces the adhesion and causes loss of power.

See that the pulleys are always in line and the shafts parallel. This is necessary for a true running belt.

Use roller forks on shifters wherever possible.

Make all joints right and straight. Use a square when cutting belts.

When measuring the length of a belt, use a steel tape or steel wire. Twine or string is subject to stretch and shrinkage and will not give exact lengths.

Tighten fasteners well and inspect them from time to time.

Watch the pins in hinge joints and replace them before they break.

Always put belts wider than 6″ or 8″ on pulleys by means of clamps.

Do not use endless belts where there is no take-up.

The best distance from center to center of shafts is from 20 to 25 feet.

Belts should be cleaned and greased every five to six months.

It is safe and advisable to use: A double belt on a pulley 12″ in diameter or larger; a triple belt on a pulley 20″ in diameter or larger, a quadruple belt on a pulley 30″ in diameter or larger.

Rubber belts ought always to be kept free from grease or animal oils. If they slip, moisten the inside of the belt with boiled linseed oil. Some fine chalk sprinkled on over the oil will help the belt.

The resistance of belts to slipping is independent of their breadth, consequently there is no advantage derived in increasing that dimension beyond what is necessary to enable the belt to resist the strain to which it is subject.

The ratio of friction to pressure for belts running over wood drums is for leather belts, when worn .47, when new .5, and when running over turned cast iron pulleys .24 and .47.

With high speed belting the tension of the belt should be increased in order to prevent the belt from slipping. Long belts are more effective than short ones.

The upper side of the pulley should always carry the slack belt.

To throw a belt on to its pulleys properly after it has been laid on requires that it should always be laid first over the pulley that is not in motion, and then be thrown over the edge of the moving pulley to its face.

It has been ascertained by trial that a belt will transmit about 30% more power with a given tension, when the grain (smooth side of the leather) is in contact with the pulley, than when the flesh side is turned inward. The leather is also less liable to crack, as the structure on the flesh side is less dense, and the fibres more extensible. The adhesion of belts is greater on polished pulleys than on rough pulleys, and is about 50% greater on a leather-covered pulley than on a polished iron pulley. Large pulleys and drums may be covered with narrow strips of leather or with longer strips wound spirally. Pulley covers are manufactured in strips of the desired width and reduced to a minimum thickness by machinery.

Belts are thoroughly stretched during process of manufacture. In fact, all stretch desirable is removed, but rolling and unrolling an endless belt tends to shorten it. This is due to the fact that the cotton duck resets somewhat into its original position, but this reset comes out immediately when the belts are placed in position on the pulleys.

* * * *

Shafts and Pulleys

Shafting and pulleys should be in perfect alignment, and pulleys should not be so widely spaced as to cause the belt to sag unduly. Idlers should not be used unless unavoidable, but when used, should be in perfect alignment with pulleys and run on the slack side of the belt, near the small pulley.

Vertical Drives * * * *

Vertical drives should be avoided, but, where necessary, distance between centers should be short. Cross drives are very injurious to rubber belts, chafing the edges and causing separation and quick disintegration of the belt.

Speed of Belts * * * *

The maximum speed at which a rubber belt should be operated is 5,000 feet per minute, and greater life and economy is obtained where the speed is kept inside of 4,000 feet per minute.

Size of Pulleys * * * *

One of the most common causes of failure in belting is the use of small pulleys, which adds to the strain on the outer plies of the belt; and too narrow belts. Pulleys should, therefore, be as large in diameter as conditions will permit, thus increasing the arc of contact of the belt and easier transmission of power.

Sag of Belts * * * *

In the location of shafts that are to be connected with each other by belts, care should be taken to secure a proper distance one from the other. This distance should be such as to allow of a gentle sag to the belt when in motion.

A general rule may be stated thus: Where narrow belts are to be run over small pulleys 15 feet is a good average, the belt having a sag of 1½ to 2 inches.

For large belts, working on larger pulleys, a distance of 20 to 25 feet does well, with a sag of 2½ to 4 inches.

For main belts working on very large pulleys, the distance should be 25 to 30 feet, the belts working well with a sag of 4 to 5 inches.

If too great a distance is attempted, the belt will have an unsteady flapping motion, which will destroy both the belt and machinery.

* * * *

Applying Belts to Pulleys

For endless belts the best method is to take both shafts out, place the belt in position on the pulleys, and then restore the shafts to their bearings. Where belts are laced with lace leather, hooks or wire lacing, the belt can be placed in position over the pulleys and the ends drawn together with belt clamps, when lacing can be readily done.

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Helpful Hints on Belts---Continued

EVILS OF TIGHT BELTS

Clamps with powerful screws are often used to put on belts with extreme tightness, and with most injurious strain upon the leather. They should be very judiciously used for horizontal belts, which should be allowed sufficient slackness to move with a loose undulating vibration on the returning side, as a test that they have no more strain imposed than is necessary simply to transmit the power.

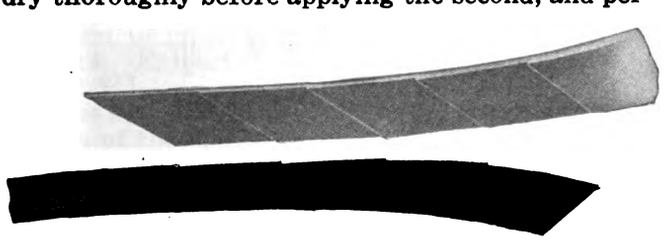
On this subject a New England cotton mill engineer of large experience says: "I believe that three-quarters of the trouble experienced in broken pulleys, hot boxes, etc., can be traced to the fault of tight belts. The enormous and useless pressure thus put upon pulleys must in time break them, if they are made in any reasonable proportions, besides wearing out the whole outfit, and causing heating and consequent destruction of the bearings." Below are figures showing the power taken, in average modern mills with first-class shafting, to drive the shafting alone:

Mill No.	Whole Load H. P.	Shafting Alone		Mill No.	Whole Load H. P.	Shafting Alone	
		H. P.	% of Whole			H. P.	% of Whole
1	199	51.0	25.6	5	759	172.6	22.7
2	472	111.5	23.6	6	235	84.8	36.1
3	486	134.0	27.5	7	670	262.9	39.2
4	677	190.0	28.1	8	677	182.0	26.8

"These may be taken as a fair showing of the power that is required in many of our best mills to drive shafting. It is unreasonable to think that all that power is consumed by a legitimate amount of friction of bearing and belts. There can be no cause for such a loss of power but tight belts."

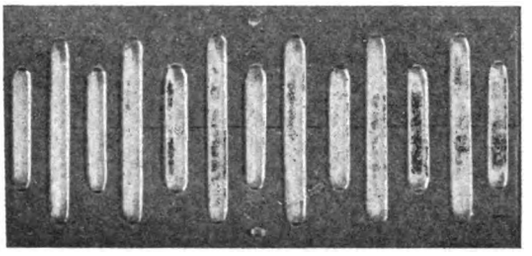
LAP SPLICE

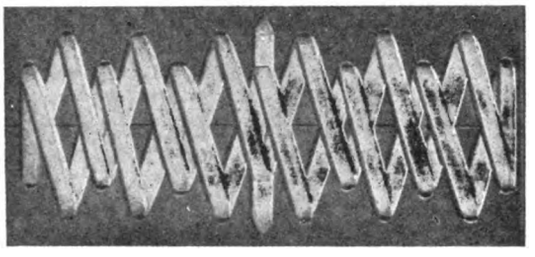
To make a lap splice, step the ends of the belt as shown in cut, allowing three to four inches for each ply of cotton duck. Care should be used not to cut into the ply below the one to be removed. The exposed duck should then be given two good coats of rubber belt cement, permitting the first coat to dry thoroughly before applying the second, and permitting the second to dry before uniting the plies. The duck should be lapped about one-eighth and then rolled down thoroughly. A hammer or heavy mallet can be used in place of a roller if more convenient. The splice should then be riveted with copper rivets, being careful that the holes for rivets are not punched larger than the shank of the rivet. In small belts the splice may be laced instead of riveted if desired.



LACING RUBBER BELTS

Cut the ends absolutely square. Allow for stretch by cutting the belt shorter than the tape measurement around the pulleys, by 1/8" to 1/4" per foot. For 3-ply belt allow 1/4" to the foot, 4 or 5-ply 3/16" to the foot, 6-ply 1/8" to the foot. Punch two rows of holes, the first row 7/8" from the end and 3/4" from the side; the second row 1 7/8" from the end and 1 1/8" from the side. Holes should be not



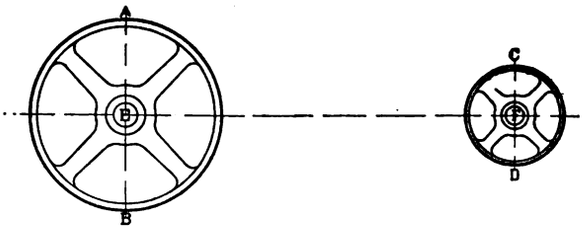


less than 3/4" apart. Draw the belt up as tight as possible, using rods and clamps. Begin lacing in the center of the belt, lacing both sides with equal tension. Take care not to cross the lace on the pulley side. For wide belts a reinforcement can be placed on the back of the joint, consisting of a thin piece of leather or rubber, equal in length to the width of the belt; this should be sewed or riveted.

• • • •

Belts are more durable and work more satisfactorily made narrow and thick, rather than wide and thin.

FORM OF ORDER FOR ENDLESS BELTS



Please send us.....Endless Belt.....inches wide, ...-ply, ...quality. Diameter of large pulley (A to B).....ft.....inches. Diameter of small pulley (C to D).....ft..... inches. Distance from center to center of shafts (E to F).....ft.....inches.

Fast running belts when made endless give best results, as a uniform thickness is assured.

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CARE OF RUBBER BELTS

In placing a 36-in. eight-ply rubber belt on pulleys 50 ft. between centers, allow ⅛-in. per running foot for stretch. Put on the clamps, as shown in Fig. 2, and draw them tight. Do not be afraid of breaking the belt, as even a five-ply 10-in. belt will stand a strain of 10,000 lb. and larger ones in proportion; the pulley will collapse first. Take all the tension the bearings will stand, then turn the shaft slowly back and forth until the clamps touch the pulleys; taking up the slack as it is recovered from the upper half. Neglect to do this will stretch only one-half of the belt, and is apt to cause it to run out of line.

After thoroughly stretching, proceed with the lap, which in this case should be 45 in. long. It should always point in the direction of travel over the pulley, as in Fig. 1. Thus any slip of the pulley will have a tendency to smooth down the lap. Place a board on the clamp rods on which to rest the splice and draw a line squarely across the belt 47 in. from the end. Lay the section off in 2-in. squares, starting 1 in. from the outer edge, as in Fig. 2. Punch ¼-in. holes where the lines cross. As there are eight plies, there will be three cuts or scarfs. Cut a line just the depth of two plies at the 45-in. line and peel off these two thicknesses; do the same at the 15- and 30-in. lines.

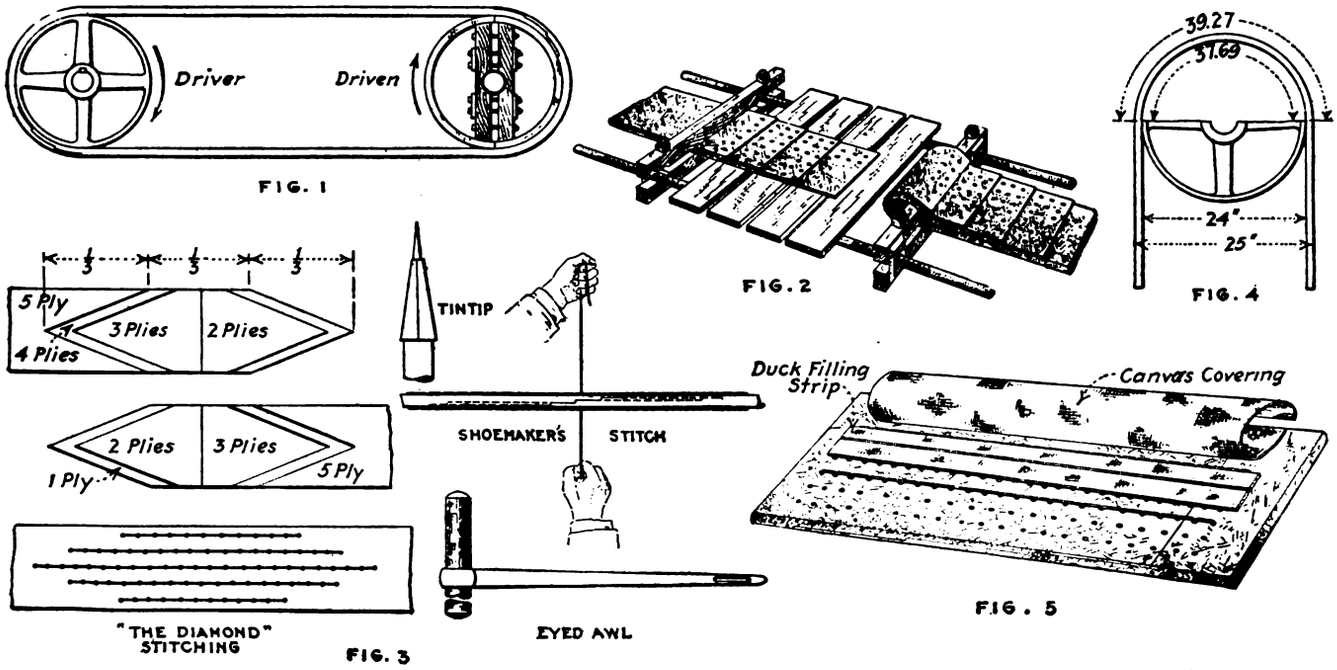
Scarf the other end, place the halves together and punch holes in the lower half, inserting the punch in the holes in the upper half. By so doing, the holes will be directly opposite each other. Cleanse the surfaces with naphtha and apply a liberal coating of the best rubber cement. Allow this to dry until it will not stick to the fingers, then place the laps together, starting at the edge and rolling the upper one out as it is being cemented, so that air may not be entrapped between the surfaces. Sew the outer edges, using the shoemaker's stitch, shown in Fig. 3. Alternately roll and pound the joint until it is perfectly flat, then sew each row of holes as was done with the outer ones.

Cut filling strips of duck the width of the space between lacings (most belt companies sell this duck all prepared) and give them several coats of rubber cement on each side. Clean the face of the belt between the laces with naphtha and give it a liberal coating of cement. When each surface is dry, that is, when the finger placed lightly to the surface will not adhere, place the strips between the lacing and roll them down. Now take a piece of duck, the width of the splice, but 4 in. longer, and cement this to the face of the belt, covering the joint. By so doing the lacings are protected and, except for the occasional renewal of the outer covering the joint is as durable as the belt itself. The manner of this is shown in Fig. 5.

For sewing, tip the laces like a shoe string by bending a V-shaped piece of tin around the ends, as illustrated, or use the eyed awl shown, to pull the lace through.

Another form of joint, known as the "diamond splice," is used on generators with small pulleys, as there is less shock when the lap passes over the pulley, eliminating all flicker of the lamps. The diamond splice is made in much the same manner as the lap splice except that the scarfs are divided into three equal parts and cut as shown in Fig. 3; it is not so strong a joint as the lap splice, but is more flexible and, therefore, better adapted to small pulleys.

Animal fats and grease should never be used on rubber belts. Boiled linseed oil is good; also equal parts of black lead, red lead, French yellow, litharge and enough japan dryer to make it dry quickly. This will give a smooth polished surface.



Stitchings, Splices and Tools Used in Repairing Rubber Belts.

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Belt Rules and Formulas

To Find the Belt Speed in Feet, Per Minute

Multiply diameter in inches, of one pulley, by 3.14; divide the result by 12, and then multiply again by the revolutions per minute, of shaft, on which this particular pulley is mounted.

If you have determined the necessary belt speed, by means of this rule, and want to find out either the RPM of the shaft—by using a certain diameter of pulley—or, if, at a given RPM, you want to find out the necessary diameter of pulley, then use the following additional rules:

To Find the RPM:

$$\frac{S \times 12}{D \times 3.14} = \text{RPM}$$

To Find Diameter of Pulley:

$$\frac{S \times 12}{\text{RPM} \times 3.14} = D$$

In these rules

S is speed per minute in feet
D is diameter of pulley in inches
RPM is revolutions of shaft per minute

* * * *

To Calculate Length of Belt When It Is Inconvenient to Use a Tape

(a) Where pulleys are of equal or nearly equal diameters, and on long centers—Add the diameters in inches of both pulleys together; divide the result by 2, and multiply by 3.14. Then divide by 12 and add twice the distance in feet between the centers of shafts.

(b) Where pulleys differ considerably in diameter, and on short centers—Add the diameters in inches of both pulleys together; divide the result by 2, and multiply by 3.14. Then divide by 12 and add thereto an amount found thus: Subtract half the diameter in feet of the smaller pulley from half the diameter of the larger pulley; multiply the remainder by itself. Add thereto the square of the center to center distance of shafts, in feet, and then extract the square root of this sum, and multiply by 2.

* * * *

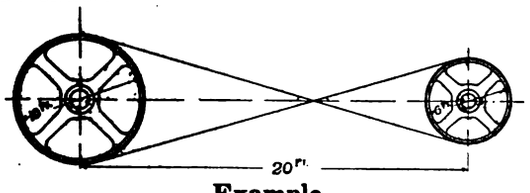
To Find the Length of a Crossed Belt

A—Multiply the sum of the diameters by 1.57.

B—Divide the square of the difference between the diameters of both pulleys by four times the distance between centers.

C—Square the sum of the radii of the pulleys and add to it the square of the distance between centers. Extract the square root and multiply by two.

The sum of A, B and C will give the approximate length of the belt, which will in nearly all cases be almost exact.

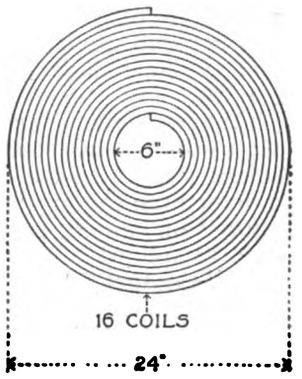


Example

A	10+6=16×1.57=	25.12
B	4×4=16÷80=	.20
C	64+400=464=21.54×2=	43.08
	Length of belt	68.40

To Calculate the Approximate Length in Any Roll of Belting

Add together the diameter of roll and diameter of hole, both in inches; divide the result by 2. Multiply by 3.14 and by the number of coils in the roll. This gives the length in inches. Divide by 12, and you have the approximate number of feet in the roll.



Example:

$$\frac{24+6}{2} = 15$$

$15 \times 3.14 \times 16 = 753.6$ inches

$$\frac{753.6}{12} = 62.8 \text{ feet, or } 62' \ 9\tfrac{1}{2}''$$

* * * *

Tension

More belts and machinery are injured by lack of proper understanding of this subject, than by any other cause. Vertical belts require extra (not excessive) tension, as it is necessary to obtain sufficient friction on the lower pulley. As far as possible avoid vertical transmission.

There are no absolute rules on this subject, as the conditions under which belts are used vary in many respects. From observations made by engineers we suggest the following schedule:

For 3-ply belt, 30 to 40 lbs. per inch of width of belt.
For 4-ply belt, 50 to 70 lbs. per inch of width of belt.
For 5-ply belt, 70 to 90 lbs. per inch of width of belt.
For 6-ply belt, 90 to 110 lbs. per inch of width of belt.
For 7-ply belt, 110 to 130 lbs. per inch of width of belt.
For 8-ply belt, 130 to 150 lbs. per inch of width of belt.

Care should be taken that the tension is never sufficient to heat the bearings. Excessive tension is injurious.

* * * *

Comparison of Rubber and Leather Belting

In the following, rubber belting made from 32 ounce cotton duck has been taken as a basis for comparison:

2-ply rubber belt equals light single leather belt.
3-ply rubber belt equals medium single leather belt.
4-ply rubber belt equals heavy single leather belt.
5-ply rubber belt equals light double leather belt.
6-ply rubber belt equals medium double leather belt.
7-ply rubber belt equals heavy double leather belt.
8-ply rubber belt equals triple leather belt.

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Belt Rules and Formulas—Continued

BELT FORMULAS

Provided the pulleys are of ample size, the following simple rules are conservative and reliable under ordinary conditions of service:

Where pulleys are of unequal diameter, before consulting table C determine the arc of contact on smaller pulleys, as follows:

Arc of Contact

Divide the difference between the radii of the two pulleys in inches by the distance between their centers, also in inches, and multiply the quotient by 115. This result subtracted from 180 will be the arc of contact of belt on smaller pulley, stated in degrees.

HORSE POWER TRANSMITTED BY LEATHER BELTS—TABLE A
Single Belts 1 Inch Wide. 800 Feet Per Minute—1 Horse Power

Speed in Feet per Minute	WIDTH OF BELT IN INCHES											
	2	3	4	5	6	8	10	12	14	16	18	20
	Horse Power											
400	1	1½	2	2½	3	4	5	6	7	8	9	10
600	1½	2¼	3	3¾	4½	6	7½	9	10½	12	13½	15
800	2	3	4	5	6	8	10	12	14	16	18	20
1000	2½	3¾	5	6¼	7½	10	12½	15	17½	20	22½	25
1200	3	4½	6	7½	9	12	15	18	21	24	27	30
1500	3¾	5⅝	7½	9⅜	11¼	15	18¾	22½	26¼	30	33¾	37
1800	4½	6¾	9	11¼	13½	18	22½	27	31½	36	40½	45
2000	5	7½	10	12½	15	20	25	30	35	40	45	50
2400	6	9	12	15	18	24	30	36	42	48	54	60
2800	7	10½	14	17½	21	28	35	42	49	56	63	70
3000	7½	11¼	15	18¾	22½	30	37½	45	52½	60	67½	75
3500	8¾	13	17½	22	26	35	44	52½	61	70	79	88
4000	10	15	20	25	30	40	50	60	70	80	90	100
4500	11¼	17	22½	28	34	45	57	69	78	90	102	114
5000	12½	19	25	31	37½	50	62½	75	87½	100	112	125

HORSE POWER TRANSMITTED BY LEATHER BELTS—TABLE B
Double Belts 1 Inch Wide. 550 Feet Per Minute—1 Horse Power

Speed in Feet Per Minute	WIDTH OF BELT IN INCHES										
	4	6	8	10	12	14	16	18	20	22	24
	Horse Power										
400	2¾	4¼	5¾	7¼	8½	10	11½	13	14½	16	17½
600	4¼	6½	8¾	11	13	15	17½	19½	22	24	26
800	5¾	8½	11½	14½	17½	20½	23	26	29	32	34½
1000	7¼	11	14½	18¼	21½	25½	29	32½	36	40	43½
1200	8½	13	17½	22	26	30¾	34½	39	44	48	52½
1500	10¾	16¼	21¾	27¼	32½	38	43½	49	54½	60	65½
1800	13	19½	26	32¾	39	45½	52	59	65½	72	78½
2000	14½	21¾	29	36½	43½	50½	58	65½	72½	80	87
2400	17½	26	34¾	44	52½	60½	69½	78½	88	96	105
2800	20½	30½	40½	51	61	71	81	91½	102	112	122
3000	21¾	32½	43½	54½	65½	76	87½	98	108	120	131
3500	25½	38	50¾	63½	76	89	101	114	127	140	153
4000	29	43½	58¼	72¾	87	101	116	131	147	160	174
4500	32½	49	65	82	98	114	131	147	163	180	196
5000	36½	54½	72¾	91	109	127	145	163	182	200	218

TABLE SHOWING HORSE-POWER TRANSMITTED BY LEATHER BELT ONE INCH WIDE AS AFFECTED BY THICKNESS

Velocity Ft. per Sec.	LACED BELTS—TENSION 275 LBS. Thickness in Inches							Velocity Ft. per Sec.	RIVETED BELTS—TENSION 400 LBS. Thickness in Inches						
	1/7	1/6	3/16	7/32	¼	5/16	⅓		7/32	¼	5/16	⅓	⅜	7/16	½
10	0.51	0.59	0.63	0.73	0.84	1.05	1.18	15	1.69	1.94	2.42	2.58	2.91	3.39	3.87
15	0.75	0.88	1.00	1.16	1.32	1.66	1.77	20	2.24	2.57	3.21	3.42	3.85	4.49	5.13
20	1.00	1.17	1.32	1.54	1.75	2.19	2.34	25	2.79	3.19	3.98	4.25	4.78	5.57	6.37
25	1.23	1.43	1.61	1.88	2.16	2.69	2.86	30	3.31	3.79	4.74	5.05	5.67	6.62	7.58
30	1.47	1.72	1.93	2.25	2.58	3.22	3.44	35	3.82	4.37	5.46	5.83	6.56	7.65	8.75
35	1.69	1.97	2.22	2.59	2.96	3.70	3.94	40	4.33	4.95	6.19	6.60	7.42	8.66	9.90
40	1.90	2.22	2.49	2.90	3.32	4.15	4.44	45	4.85	5.49	6.86	7.32	8.43	9.70	10.98
45	2.09	2.45	2.75	3.21	3.67	4.58	4.89	50	5.26	6.01	7.51	8.02	9.02	10.52	12.03
50	2.27	2.65	2.98	3.48	3.98	4.97	5.30	55	5.68	6.50	8.12	8.66	9.74	11.36	13.00
55	2.44	2.84	3.19	3.72	4.26	5.32	5.69	60	6.09	6.96	8.70	9.28	10.43	12.17	13.91
60	2.58	3.01	3.38	3.95	4.51	5.64	6.02	65	6.45	7.37	9.22	9.83	11.06	12.90	14.75
65	2.71	3.16	3.55	4.14	4.74	5.92	6.32	70	6.78	7.75	9.69	10.33	11.62	13.56	15.50
70	2.81	3.27	3.68	4.29	4.91	6.14	6.54	75	7.09	8.11	10.13	10.84	12.16	14.18	16.21
75	2.89	3.37	3.79	4.42	5.05	6.31	6.73	80	7.36	8.41	10.51	11.21	12.61	14.71	16.81
80	2.94	3.43	3.86	4.50	5.15	6.44	6.86	85	7.58	8.66	10.82	11.55	13.00	15.16	17.32
85	2.97	3.47	3.90	4.55	5.20	6.50	6.93	90	7.74	8.85	11.06	11.80	13.27	15.48	17.69
90	2.97	3.47	3.90	4.55	5.20	6.50	6.93	100	7.96	9.10	11.37	12.13	13.65	15.92	18.20

H. P. becomes maximum at 87.41 feet per second.

H. P. becomes maximum at 105.4 feet per second.

In the following formulas:

H. P.=Horse power.
W=Width of belt in inches.
D=Diameter of driven pulley.
S=Speed of belt or surface speed of pulley in feet per minute.

Horse Power

To find the horse power that will be transmitted, speed of pulley and width of belt being given:

$$H.P. = \frac{W \times S}{600}$$

Width of Belt

To find the width of belt required to transmit a given horse power, speed of pulley being given:

$$W = \frac{H.P. \times 600}{S}$$

Speed Required

To find the speed necessary to transmit a given horse power, width of belt being known:

$$S = \frac{H.P. \times 600}{W}$$

NOTE—Results are for 4-ply belts, on pulleys of equal size, or 180 degrees arc of contact. Where other plies are used, or where pulleys are unequal in diameter, multiply by the decimal as shown in table C.

TABLE SHOWING HORSE POWER TRANSMITTED PER INCH OF WIDTH OF BELT FOR EACH 600 FEET OF SPEED PER MINUTE—TABLE C

Arc of contact on pulley of	Horse Power for				
	4-ply	5-ply	6-ply	7-ply	8-ply
180 degrees	1.00	1.20	1.40	1.60	1.80
170 degrees	.97	1.16	1.35	1.55	1.74
160 degrees	.94	1.12	1.31	1.50	1.69
150 degrees	.91	1.09	1.27	1.45	1.64

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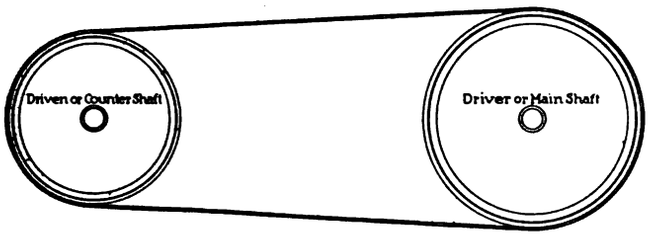
Power Transmission Data

RULES FOR DETERMINING SIZE AND SPEED OF PULLEYS

The driving pulley is called the Driver, and the driven pulley the Driven.



When the diameter of the Driven and its revolutions, and also revolutions of Driver are given, the DIAMETER OF THE DRIVER equals:

$$\frac{\text{Diam. of Driver} \times \text{Rev. of Driven}}{\text{Revolutions of Driver}}$$

When the revolutions of the Driven and diameter and revolutions of the Driver are given, the DIAMETER OF THE DRIVEN equals:

$$\frac{\text{Diam. of Driver} \times \text{Rev. of Driver}}{\text{Revolutions of Driven}}$$

When the diameter and revolutions of the Driven and diameter of the Driver are given, the REVOLUTIONS OF THE DRIVER equals:

$$\frac{\text{Diam. of Driven} \times \text{Rev. of Driven}}{\text{Diameter of Driver}}$$

When the diameter and revolutions of the Driver, and diameter of the Driven are given, the REVOLUTIONS OF THE DRIVEN equals:

$$\frac{\text{Diam. of Driver} \times \text{Rev. of Driver}}{\text{Diameter of Driven}}$$

Formula for Prime Mover—"Head Shaft."

$$\text{H. P.} = \frac{\text{Diameter}^3 \times \text{R. P. M.}}{80}$$

Formula for Second Mover—"Line Shaft."

$$\text{H. P.} = \frac{\text{Diameter}^3 \times \text{R. P. M.}}{60}$$

TABLE OF HORSE POWER OF MANILA TRANSMISSION ROPE AT VARIOUS SPEEDS

Diameter of Rope in Inches	SPEED OF THE ROPE IN FEET PER MINUTE								Approximate Weight per Foot	Smallest Diam. of Sheaves in Feet
	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000		
⅝	2.8	3.2	3.6	4.2	4.6	5.0	5.3	5.3	.16	1½
¾	3.3	4.3	5.2	5.8	6.7	7.2	7.7	7.7	.20	2½
⅞	4.5	5.9	7.0	8.2	9.1	9.8	10.8	10.7	.33	3
1	5.8	7.7	9.2	10.7	11.9	12.8	13.6	13.7	.42	3½
1⅛	7.5	9.9	11.7	13.7	15.4	16.4	17.4	17.7	.47	4
1¼	9.2	12.1	14.3	16.8	18.6	20.0	21.2	21.4	.60	4½
1⅜	11.2	15.0	17.5	19.9	22.7	24.4	25.9	26.1	.70	5
1½	13.1	17.4	20.7	23.1	26.8	28.8	30.6	30.8	.80	5
1¾	18.0	23.7	28.2	32.8	36.4	39.2	41.5	41.8	1.15	6
2	23.1	30.8	36.8	42.8	47.6	51.2	54.4	54.8	1.35	7

HORSE-POWER TRANSMITTED BY A STEEL ROPE ON WOOD-FILLED SHEAVES

Diam. of Rope Inches	Velocity of Rope in Feet Per Second									
	10	20	30	40	50	60	70	80	90	100
¼	4	8	13	17	21	25	28	32	37	40
5/16	7	13	20	26	33	40	44	51	57	62
⅜	10	19	28	38	47	56	64	73	80	89
7/16	13	26	38	51	63	75	88	99	109	121
½	17	34	51	67	83	99	115	130	144	159
9/16	22	43	65	86	106	128	147	167	184	203
⅝	27	53	79	104	130	155	179	203	225	247
11/16	32	63	95	126	157	186	217	245	...	...
¾	38	76	103	150	186	223	...	...	...	...
⅞	52	104	156	206	...	...	...	...	...	...
1	68	135	202	...	...	...	...	...	...	...

The horse-power that may be transmitted by iron ropes is one-half of the above. The above horse-powers are for ropes working under the maximum safe working tensions. It would be well, therefore, to allow a small margin to take care of rope stretch, thus avoiding the necessity of taking up small amount of stretch. With rubber and leather-filled sheaves, the amount of horse-power capable of being transmitted is 40 per cent. greater than for wood, so that they are generally used. The transmission of horse-powers greater than 250 is impractible with filled sheaves, as the tension would be so great that the filling would be quickly cut out.

* * * *

Belt-clamps having spring-balances between the two pairs of clamps should be used for weighing the tension of the belt accurately each time it is tightened.

* * * * *

In figuring the total expense of belting and the cost chargeable to this account, by far the largest item is the time lost on the machine while belts are being replaced and repaired.

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Power Transmission Data

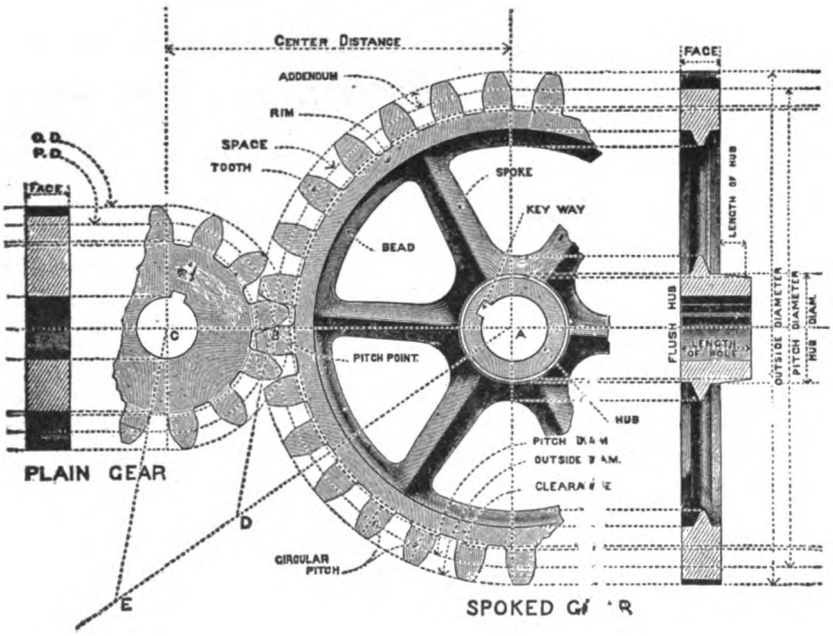
RULES AND DEFINITIONS FOR GEARS

The cut below shows a pair of common spur gears and names the principal parts.

Spur gears are gears on parallel axes. Internal gears and racks and some forms of spiral gears are spur gears.

Theoretically the teeth of spur gears may be of any desired size, but, as they must be shaped by expensive cutters of fixed forms, they are practically confined to certain definite shapes and sizes known as "standard" forms and pitches.

The "diametral pitch" is the number of teeth in a gear per inch of its pitch diameter, and calculations by its use are very simple. Thus, if a gear has a four-inch pitch diameter and is of 12 pitch, it must have four times 12, or 48 teeth. If a gear has 37 teeth and is of 8 pitch, its pitch diameter must be 37 divided by 8, or 4⅝ inches.



The outside diameter of a spur gear is larger than its pitch diameter by two "pitchparts"; thus, any gear of 7 pitch has an outside diameter two-sevenths of an inch larger than its pitch diameter. This does not apply to bevel gears.

If the center distance AC is given, and the pitch point B, at which the pitch lines roll together, is required for a pair of gears of a given proportion, lay off the distance AD and DE in the given proportion and in any direction, draw EC and then DB parallel to EC will fix the point B. The radii BC and AB must now be divisible by half a pitch, part of the pitch to be used; thus, if the gears are to be cut 8 pitch, there must be a whole number of sixteenths of an inch in both AB and BC.

It should be remembered that the pitch of a gear must be a regular standard pitch, also that the length of the hub is the part that projects beyond the rim, and not the apparent length, and it is much better to give the length of the hole rather than that of the hub.

The word "diameter," when applied to any gear, means its pitch diameter, and not its measured or "outside" diameter.

Diametral Pitch of a gear is the number of teeth to each inch of the pitch diameter.

Circular Pitch is the distance from the center of one tooth to the center of the next, measured along the pitch line.

The Circular Pitch is equal to the constant 3.1416 divided by the diametral pitch.

To Find Diametral Pitch from number of teeth and pitch diameter, divide the number of teeth by the pitch diameter.

To Find Diametral Pitch from number of teeth and outside diameter, add 2 to the number of teeth and divide by the outside diameter.

The Number of Teeth in a gear is equal to the pitch diameter multiplied by the diametral pitch.

To Find Pitch Diameter from number of teeth and pitch, divide the number of teeth by the diametral pitch.

To Find Outside Diameter, add 2 to the number of teeth and divide by the pitch.

To Find the Whole Depth of a Tooth, divide 2.157 by the diametral pitch, or take .6866 of the circular pitch.

To Find Thickness of a Tooth at the pitch line, divide the circular pitch by 2, or 1.57 by the diametral pitch.

To Find Center Distance of a pair of gears, add the number of teeth together and divide one-half the sum by the diametral pitch.

To Find the Number of Teeth in a gear and pinion, multiply center distance by two times the diametral pitch, and divide product by ratio of pinion plus ratio of gear. This quotient multiplied by ratio of pinion equals number of teeth in pinion, and by ratio of gear equals number of teeth in gear.

Addendum is the distance from the pitch circle to the outside diameter.

Dedendum is the distance from the pitch circle to the bottom of the working depth.

Clearance is the distance from the working depth to the bottom of the tooth.

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HERRINGBONE GEARS

Standard Cut Herringbone Gears (Hobbing Process). Cut up to 1¼ D. P. The face should be made not less than six times the circular pitch, as in table:

D. P.	C. P.	Min. Face	D. P.	C. P.	Min. Face
10	.314"	2 "	3	1.04"	6½"
8	.392"	2½"	2½	1.15"	7½"
6	.523"	3½"	2	1.57"	9½"
5	.628"	4 "	1¾	1.79"	11 "
4	.785"	5 "	1½	2.09"	12½"
3½	.897"	5½"	1¼	2.51"	15 "
			1	3.142"	18 "

Standard Hobbed Teeth are always 23° helical angle, 20° involute stub teeth.

Standard herringbone gearsare cut both halves of the same tooth at one time, which requires a groove in the center of the face for hob clearance. To avoid under cutting of the teeth in pinions of 17 teeth or less, it has been found desirable to use special diameters. The pitch and pitch diameter for standard herringbone hobbed gears is designated the same as spur gears using diametral pitches only. The pitch diameter is calculated by the same method as for spurs.

$$P.\ D. = \frac{\text{No. of teeth}}{D.\ P.}$$

The outside diameter = P. D. plus $2\left(\frac{8}{DP}\right)$ plus or minus modifications for 17 teeth or less given in Table 2.

Horse power transmitted by standard cut herringbone gears may be found from the following formula:

$$H.\ P. = \frac{VSPFYK}{33000}$$

V = Velocity of Pitch line in ft. per min. S = Fiber-Stress; forged steel, 10,000; cast steel, 7,500; cast iron and semi-steel, 4,000; pronze, 5,000. P = Circular Pitch. F = Total Face. K = Speed factor opposite. Y = Tooth factor opposite.

T.	Y.	V. Ft. per Min.	K.
12	.08		
15	.09	100	.95
19	.1	500	.85
25	.11	1000	.75
35	.12	1500	.66
50	.13	2000	.60
80	.14	2500	.55
300	.15	3000	.50

Some reasons for using standard herringbone gears in preference to spur gears.

They will operate satisfactorily at 100 per cent. higher speeds. Are practically noiseless and free from vibration. Ratios of reduction may be double those possible with spurs. Will transmit 50 to 100 per cent. more power for equal weight than spurs. Have an efficiency of transmission about 20 per cent. higher than spurs. Are two to five times more durable than spurs. Are cut with much greater accuracy than possible with spurs. In consideration of the above, are cheaper than spurs.

See Charts and Tables, giving tooth parts, enlargement grooves of herringbone gears.

TABLE 1—Table of Tooth Parts

Diametral Pitch	Equivalent Circular Pitch	Normal Tooth Thickness at Pitch Line	Addendum	Twice Addend. or Working Depth	Deddendum	Twice Deddendum	Bottom Clearance	Whole Depth of Tooth
10.	.314	.145	.08	.160	.100	.200	.020	.180
8.	.393	.181	.100	.200	.125	.250	.025	.225
6.	.524	.241	.133	.266	.167	.334	.034	.300
5.	.628	.289	.160	.320	.200	.400	.040	.360
4.	.785	.362	.200	.400	.250	.500	.050	.450
3.50	.898	.413	.229	.458	.286	.572	.057	.515
3.	1.047	.482	.267	.534	.333	.666	.066	.600
2.50	1.256	.578	.320	.640	.400	.800	.080	.720
2.	1.571	.723	.400	.800	.500	1.000	.100	.900
1.75	1.796	.816	.457	.914	.572	1.144	.115	1.029
1.50	2.094	.964	.533	1.066	.667	1.334	.134	1.200
1.25	2.513	1.156	.640	1.280	.800	1.600	.160	1.440
1.	3.142	1.446	.8	1.6	1.00	2.00	.200	1.8

NOTE—For pinions with less than 18 teeth see Table 2.

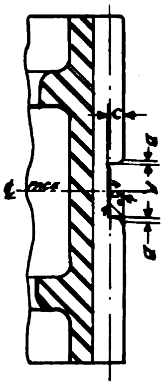
TABLE 2—Enlargement in Outside Diameter of Pinions with 17 Teeth or Less and Corresponding Decrease in Outside Diameter of Gears to Provide a Full Involute Tooth

Number of Teeth	DIAMETRICAL PITCH 10	8	6	5	4	3½	3	2½	2	1¾	1½	1¼	1
7	.1181	.1478	.1976	.2364	.2954	.3382	.3938	.4726	.5906	.6762	.7882	.945	1.181
8	.1064	.133	.1782	.2128	.2662	.3046	.3548	.4258	.5322	.6094	.7102	.8514	1.064
9	.0947	1184	.1586	.1894	.2368	.2712	.3158	.379	.4736	.5424	.6322	.7578	.9471
10	.083	.1038	.1392	.1662	.2076	2378	.2768	.3322	.4152	.4756	.5542	.6642	.8302
11	.0713	.0892	.1196	.1428	.1784	2044	.2378	.2854	.3568	.4088	.4762	.5706	.7132
12	.0596	.0746	.1002	.1194	.1492	.171	.1988	.2386	.2982	.342	.3982	.4772	.5962
13	.0479	.06	.0806	.0958	.12	.1376	.1598	.1918	.2398	.2752	.3202	.3836	.4792
14	.0362	.0454	.0612	.0726	.0906	.1042	.1208	.145	.1812	.2082	.2424	.29	.3623
15	.0245	.0308	.0416	.0492	.0614	.0708	.0818	.0982	.1228	.1414	.1644	.1964	.2453
16	.0128	.0162	.0222	.0258	.0822	.0374	.0428	.0514	.0642	.0746	.0864	.1028	.1283
17	.0011	.0016	.0026	.0024	.0028	.004	.0038	.0046	.0058	.0078	.0084	.0092	.0113
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Calculate the outside diameter as usual, then add the amount of enlargement to the pinion and subtract the same amount from the gear. Use only when pinion has 17 teeth and less.

When two enlarged pinions have to gear together, the center distance must be increased by one-half of the sum of the enlargement.

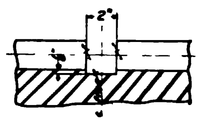
TABLE 3—Standard Groove For Hobbed Tooth Gears (8 to 1¼ D. P.)

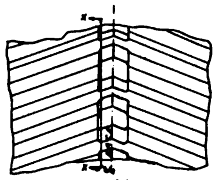


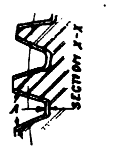
Diametral Pitch	DIMENSIONS OF GROOVE A	B	C	Number of Threads in Hob
10	1/8"	1/64"	3/32"	5
8	7/16"	1/64"	1/8"	4
8	9/16"	1/64"	1/8"	6 (Special)
6	3/4"	1/32"	5/32"	4
5	3/4"	1/32"	3/16"	4
4	1 "	3/64"	7/32"	4
4	1 1/8"	3/64"	7/32"	5 (Special)
3½	1 "	3/64"	1/4"	3
3	1 1/8"	1/16"	5/16"	3
2½	1 5/16"	1/16"	11/32"	3
2½	1 1/2"	1/16"	11/32"	4 (Special)
2	1 5/8"	3/32"	7/16"	3
1¾	1 7/8"	1/8"	1/2"	3
1½	2 3/16"	5/32"	9/16"	3
1¼	2 9/16"	3/16"	11/16"	3
1	3 1/4"	3/16"	13/16"	3

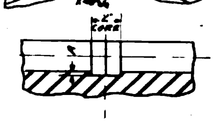
On Turbine Transmission Gears width of groove = A + 2B, depth = 2C, leave off the 45° angle, making sharp corner.

For Planed Tooth Gears (Over 1¼ D. P.)





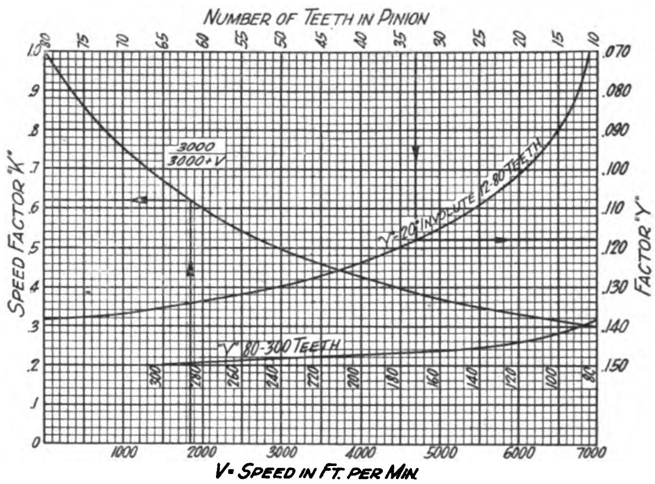




Turn groove as shown for forged steel and also castings if teeth are not cored out.

Core Pockets as shown when teeth are cored out. A = ¼" to ⅜"

STRENGTH OF HERRINGBONE GEARS



$$W = \frac{S}{2}\,PFYK$$ —(Safe for wear, well oiled). For Grease Lubrication.

W = Load in Pounds Multiply by .8 to .62.
S = Working Stress (No Speed).
P = Circular Pitch.
Y = Factor (From Curve).
F = Face in Inches.
K = Speed Factor (From Curve).

	Values of "S"	Ultimate Tensile
Chrome Nickel Steel Heat Treated....	30,000	120,000
Forge Steel—.50C..	25,000	100,000
Forge Steel—.30C..	20,000	80,000
Cast Steel.........	15,000	60,000
Cast Iron..........	8,000	24,000
Bronze 88-10-2....	10,000	30,000

EQUIVALENT VALUES OF DIAMETRAL PITCHES

D. P.	1¼	1½	1¾	2	2½	3	3½	4	5	6	8
C. P.	2.51"	2.09"	1.79"	1.57"	1.25"	1.04"	.897"	.785"	.628"	.523"	.392"
Min. Face Rec.	15"	12½"	11"	9½"	7½"	6½"	5½"	5"	4"	3½"	2½"

For Continuous Contact of Teeth Min. Face = 6 times C P.

Example: Pin. 33T.—Gear 197T.—2½ D. P.—28F.—1860 Ft. Per Min. Pitch Speed.

Material: Chrome Nickel, Heat Treated Steel Pinion, Rolled Steel Gear Rim.

$$W = 15{,}000 \times 1.25 \times 28 \times .118 \times .62 = 38{,}400 \text{ lbs.} \quad H.\ P. = \frac{W \times V}{33{,}000} = \frac{38{,}400 \times 1860}{33{,}000} = 2150\ H.\ P.$$

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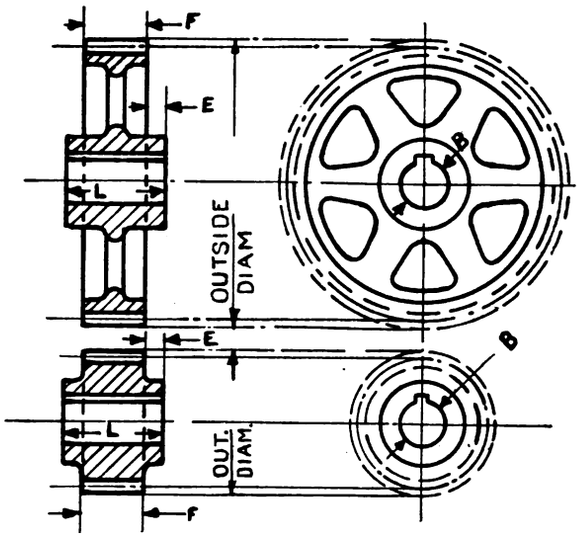
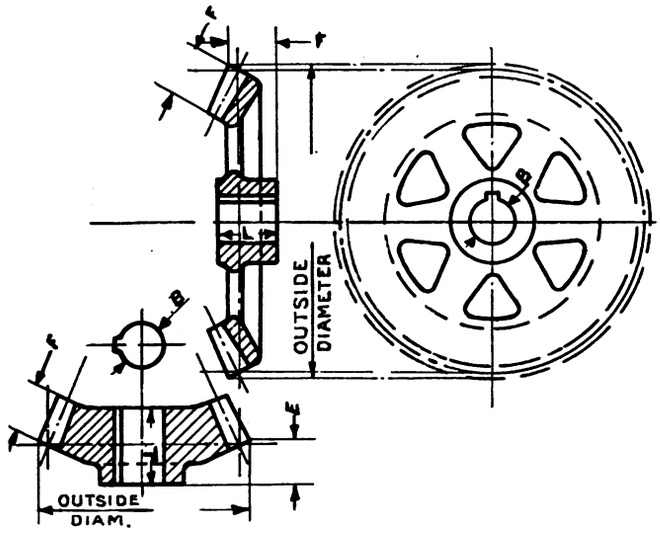
Before Ordering Gears---Read This

A common complaint made by manufacturers of gears is that mining officials in transmitting their orders for spur or bevel gears and pinions or worm wheels frequently fail to give the complete information which is needed before the part can be made.

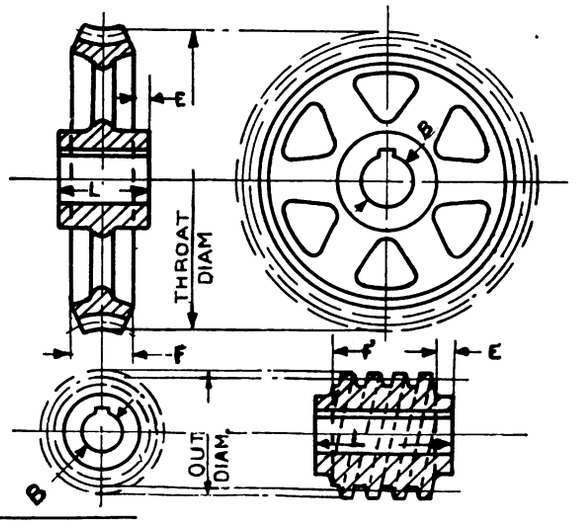
Since such parts are usually needed in haste much time and annoyance can be saved, both to the manufacturer and the mine official if the information given on this page is used as a guide. It completely covers the data needed. Do not slight a single item but give full information on each detail. Copies of this form may be had on request to the publishers of the MINING CATALOG.



SPUR GEAR	SPUR PINION
Material	Material .....
No. of Teeth	No. of Teeth .....
Outside Diam.	Outside Diam. .....
F—Face	F—Face .....
L—Hub Length	L—Hub Length .....
E—Hub Extension.....	E—Hub Extension.....
B—Hub Bore	B—Hub Bore .....
Keyway....in. by....in.	Keyway....in. by....in.
Straight or Tapered	Straight or Tapered .....
Shaft Centers (Important)	



BEVEL GEAR	BEVEL PINION
Material	Material .....
No. of Teeth	No. of Teeth .....
Outside Diam.	Outside Diam. .....
F—Face	F—Face .....
L—Hub Length	L—Hub Length .....
E—Hub Extension.....	E—Hub Extension.....
B—Hub Bore	B—Hub Bore .....
Keyway....in. by....in.	Keyway....in. by....in.
Straight or Tapered	Straight or Tapered .....
Angle of Shafts (Important) .....Degrees.	



WORM WHEEL	WORM
Material	Right / Left } Hand
No. of Teeth	
Throat Diam.	Single / Double / Triple } Thread
F—Face	Material .....
L—Hub Length	.....Pitch .....Lead
E—Hub Extension.....	Outside Diam. .....
B—Hub Bore	F—Face .....
Keyway....in. by....in.	L—Hub Length .....
Straight or Tapered	E—Hub Extension.....
Shaft Centers (Important)	B—Hub Bore .....
	Keyway....in. by....in.
	Straight or Tapered .....

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MAXIMUM SPEED OF GEARING

Ordinary gearing with cast-iron teeth, 1,800 feet per minute.

Cast-iron gearing with accurate, machine-cut teeth, 3,000 feet per minute.

Ordinary gearing with cast-iron teeth should not run over 1,200 feet per minute to avoid great noise.

EFFICIENCY OF SPUR GEARING

Efficiency of machine-cut gearing, if well lined up and not overloaded, will be as high as 98%, and under ordinary circumstances can be safely taken at 96%.

Cast-tooth gearing, under favorable conditions, show an efficiency of 95%. A safe figure under ordinary conditions is 90%.

RELATIVE SPEED OR GEAR RATIO

The following rules can be used to determine the relative speeds and the number of teeth for two gears working together:

1. Revolutions of Driving Gear = $\frac{\text{No. of Teeth} \times \text{Revs. of Driven Gear}}{\text{No. of Teeth of Driving Gear}}$

2. Revolutions of Driven Gear = $\frac{\text{No. of Teeth} \times \text{Revs. of Driving Gear}}{\text{No. of Teeth of Driven Gear}}$

3. No. of Teeth in Driving Gear = $\frac{\text{No. of Teeth} \times \text{Revs. of Driven Gear}}{\text{Revs. of Driving Gear}}$

4. No. of Teeth in Driven Gear = $\frac{\text{No. of Teeth} \times \text{Revs. of Driving Gear}}{\text{Revs. of Driven Gear}}$

HORSE POWER OF GEARS

Cast Iron

F = Breadth, or Face, of Tooth in inches.
T = Thickness of Tooth at pitch line, inches.
V = Velocity at pitch line in feet per minute.
L = Length of Tooth, from root to point, in inches.
C = Co-efficient.
H P = Horse Power transmitted with a safety of eight, ultimate tensile strength, 30,000 pounds per square inch.

FORMULAE

(1) Horse power of Spur Gears $= \frac{F \times 2^2 \times V}{L \times 53}$

(2) Horse power of Bevel Gears $= \frac{F \times 2^2 \times V}{L \times 57}$

(3) Horse power of Miter Gears $= \frac{F \times 2^2 \times V}{L \times 82}$

In formulae for Bevel and Miter Gears the factors T and L express the pitch at large end of tooth.

DIMENSIONS OF STANDARD KEYSEATS FOR GEARS

Diameter of Hole Inches	Keyseat Width Inches	Keyseat Depth Inches	Diameter of Hole Inches	Keyseat Width Inches	Keyseat Depth Inches
1/4 to 3/8	1/16	1/32	3 7/8 to 5 3/16	1	1/2
7/16 to 5/8	1/8	1/16	5 1/4 to 6 7/16	1 1/8	9/16
11/16 to 7/8	3/16	3/32	6 1/2 to 7 11/16	1 1/4	5/8
15/16 to 1 1/8	1/4	1/8	7 3/4 to 9 15/16	1 3/8	11/16
1 3/16 to 1 5/16	5/16	5/32	9 to 10 9/16	1 1/2	3/4
1 3/8 to 1 13/16	3/8	3/16	10 1/4 to 11 7/16	1 5/8	13/16
1 7/8 to 2 5/16	1/2	1/4	11 1/2 to 12 11/16	1 3/4	7/8
2 3/8 to 2 13/16	5/8	5/16	12 3/4 to 13 15/16	1 7/8	15/16
2 7/8 to 3 5/16	3/4	3/8	14 to 14 15/16	2	1
3 3/8 to 3 13/16	7/8	7/16			

HORSE-POWER SHAFTING WILL TRANSMIT

Diameter of Shaft	Weight per Foot	REVOLUTIONS PER MINUTE 100	125	150	175	200	225	250	300	350	400
15/16	2.05	1.2	1.4	1.7	2.1	2.4	2.6	3.1	3.6	4.3	5.0
1 3/16	3.77	2.4	3.1	3.7	4.3	4.9	5.5	6.1	7.3	8.5	9.7
1 7/16	5.52	4.3	5.3	6.4	7.4	8.5	9.5	10.5	12.7	14.8	16.9
1 11/16	7.61	6.7	8.4	10.1	11.7	13.4	15.1	16.7	20.1	23.4	26.8
1 15/16	10.03	10.0	12.5	15.0	17.5	20.0	22.5	25.0	30.0	35.0	40.0
2 3/16	12.80	14.3	17.8	21.4	24.9	28.5	32.1	35.6	42.7	49.8	57.0
2 7/16	15.89	19.5	24.4	29.3	34.1	39.0	44.1	48.7	58.5	68.2	78.0
2 11/16	19.31	26.0	32.5	39.0	43.5	52.0	58.5	65.0	78.0	87.0	104.0
2 15/16	23.06	33.8	42.2	50.6	59.1	67.5	75.9	84.4	101.3	118.2	135.0
3 3/16	27.16	43.0	53.6	64.4	75.1	85.8	96.6	107.3	128.7	150.3	171.6
3 7/16	31.58	53.6	67.0	79.4	93.8	107.2	120.1	134.0	158.8	187.6	214.4
3 11/16	36.40	65.9	82.4	97.9	115.4	121.8	148.3	164.8	195.7	230.7	243.6
3 15/16	41.40	80.0	100.0	120.0	140.0	160.0	180.0	200.0	240.0	280.0	320.0
4 7/16	52.58	113.9	142.4	170.8	199.3	227.8	256.2	284.7	341.7	398.6	455.6
4 15/16	65.10	156.3	195.3	234.4	273.4	312.5	351.5	390.6	468.7	546.8	625.0

The engineering data in this section has been compiled largely from the catalogs of the following manufacturers:

Allis-Chalmers Manufacturing Company
George M. Newhall Engineering Company
R. & J. Dick, Limited
New York Belting and Packing Company
Denver Engineering Works
Victor Balata & Textile Belting Company
Fawcus Machine Company
Revere Rubber Company
George C. Moon Company, Inc.
Philadelphia Gear Works

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THE B. F. GOODRICH RUBBER CO.

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Seattle, Wash.

THE INTERNATIONAL B. F. GOODRICH CORP.
London Capetown Singapore

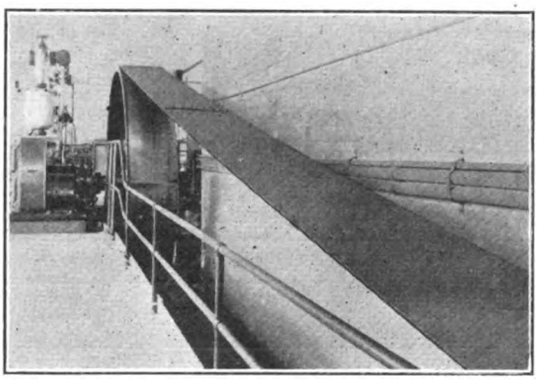
Transmission Belts for Every Duty

Mechanical Rubber Goods of Every Description

For Conveyor and Elevator Belts, see pages 662 to 666; for Air Drill Hose, see page 303; for Steam Hose and Packing, see pages 190 and 191; for Fire Protection and Water Hose and Couplings, see pages 794 and 795.

Transmission Belts For Every Duty

The difference between the right belt for a drive transmitting several hundred horsepower, or for a brute drive such as a gyratory crusher, and a belt for a small high speed fan is more than a mere matter of size. The very make-up and the physical characteristics of the belts must be different if satisfactory results are to be achieved.



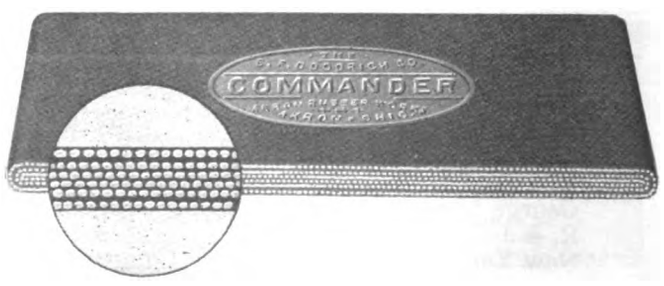
It is obviously just as unwise to attempt to drive a fan with a belt built for a gyratory crusher as it is to drive a gyratory crusher with a belt constructed to drive a high speed small pulley fan. Each belt must be designed with particular reference to its adaptability for the particular job it has to perform, and it is with this though in mind that we recommend to you, in the following paragraphs, certain of our brands for mining service.

Commander

We would be willing to rest our reputation as belt makers on the superiority of COMMANDER. With modern industry demanding more and more from every item of plant equipment and particularly from drive belts, the continued success of COMMANDER since its inception has been a substantiation of its fundamental soundness.

COMMANDER has a special extra heavy duck, the result of careful investigation of what constitutes the proper duck for heavy transmission work. This, while giving great body and tensile strength to the belt, has remarkable flexibility; consequently COMMANDER is able to stand heavy overloads with very little damage. This strong duck also gives great security at the lacings.

COMMANDER friction has plenty of strength and toughness to stand any of the strains that come upon a drive belt in the heaviest kind of service. It tests high, but there is more to it than merely the pounds pull it will stand in test. What counts is not how the friction tests when new, but how well and how long it stands up in continuous service. The friction in COMMANDER has that aging quality necessary to hold the plies to-



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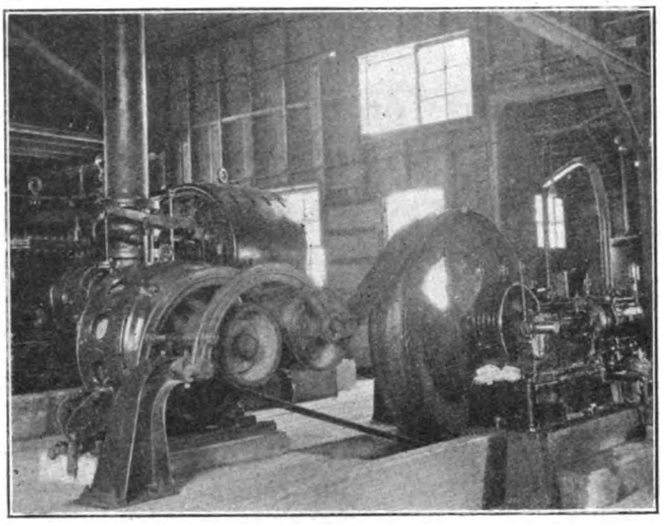
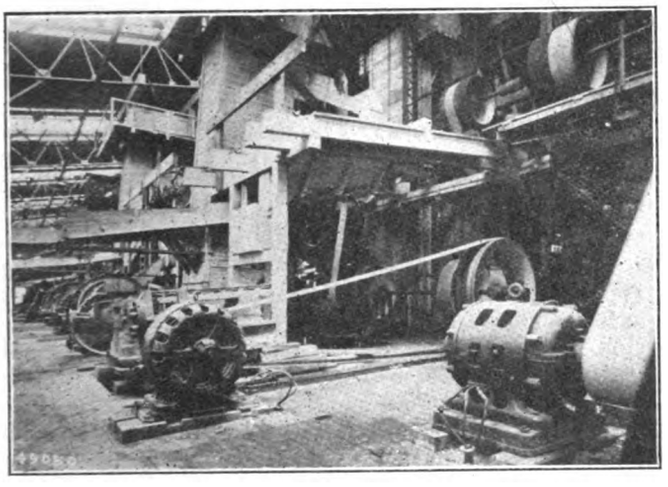
Transmission Belts for Every Duty

gether until the very end of the belt's normal usefulness.

The heavy gum cushion under the outer ply is a unique feature that contributes largely to COMMANDER'S success. This elastic cushion takes up much of the strain that tends to shear the plies apart as the belt bends over the pulleys. This gives COMMANDER an advantage over the ordinary heavy duty belt on pulleys of moderate size; the severe strains that rack the usual belt may be said to be absorbed in COMMANDER'S gum cushion. This cushion preserves all the advantages of a friction surface belt to CCMMANDER and also gives it the advantages of a covered belt. It improves the grip on the pulleys, because of the greater flexibility and resilience of the belt. It also provides insulation against direct wear on the carcass. It effectively keeps away from the interior all moisture, oils, etc.



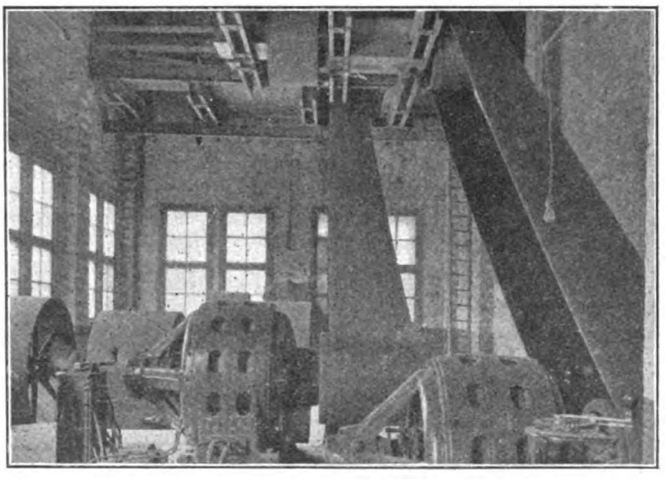


Each part of COMMANDER is perfect for its work. On account of its combined strength and flexibility, it is the ideal belt for many places where difficulty in transmission practice is experienced.

Marathon

Drive belts for operation at extreme speed over small pulleys must be of exceptional quality and flexibility. Such machines as centrifugal pumps, fans, etc., demand belts having an unusual combination of lightness and ruggedness.

MARATHON is made for this service. It has a light, closely woven duck of unusual tensile strength and ample body for the fasteners, combined with the necessary flexibility for perfect operation. It hugs the pulleys closely, reducing slippage and horsepower losses, and its strong elastic friction guarantees immunity from ply separation.



Rob Roy

There is a demand among certain classes of users for a light weight, medium priced friction surface belt, for use where the service is light or intermittent. ROB ROY meets this demand. Many are users of this belt because they have found that they get more out of it in proportion to its cost than they do out of any available competitive belts.

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LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

Branch Offices and Agencies

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Buffalo.....547 Ellicott Square
Wilkes-Barre..2nd National Bank Bldg.
Cleveland.....429 Kirby Bldg.
Huntington, W. Va., Robson-Prichard Bldg.

Detroit.....4210 Woodward Ave.
Kansas City, Mo....306 Elmhurst Bldg.
Seattle.....820 First Ave., S.
Portland, Ore.....161 First St.
San Francisco.....168 Second St.
Los Angeles.....163 N. Los Angeles St.
Denver....Lindrooth, Shubart & Co., Boston Bldg.

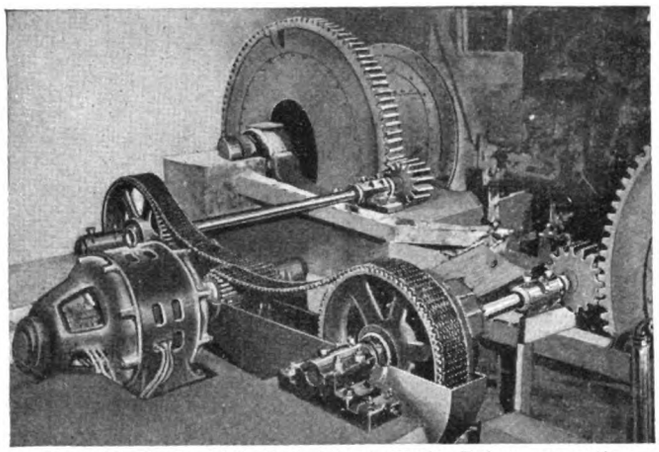
Louisville, Ky.....Frederick Wehle, Starks Bldg.
New Orleans.....C. O. Hinz, 504 Carondelet Bldg.
Birmingham, Ala.....S. L. Morrow, 720 Brown-Marx Bldg.

Canadian Link-Belt Co., Ltd., Toronto and Montreal
H. W. Caldwell & Son Co., Chicago, New York, Dallas, Texas

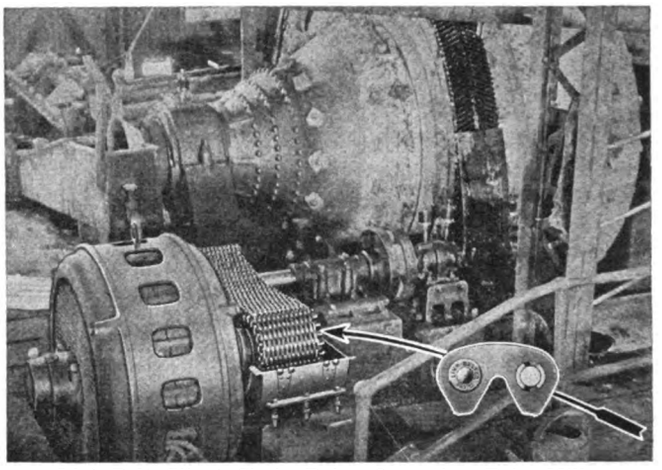
World's Largest Manufacturers of

Chains for Elevating, Conveying and Power Transmission

For Description of Other Products See Pages 499, 653, 654 and 655



Two 75 H. P. Link-Belt Silent Chain Drives operating tube and ball mills.



Link-Belt Silent Chain Drive Operating Tube Mill

Link-Belt Silent Chain for the Efficient Transmission of Power

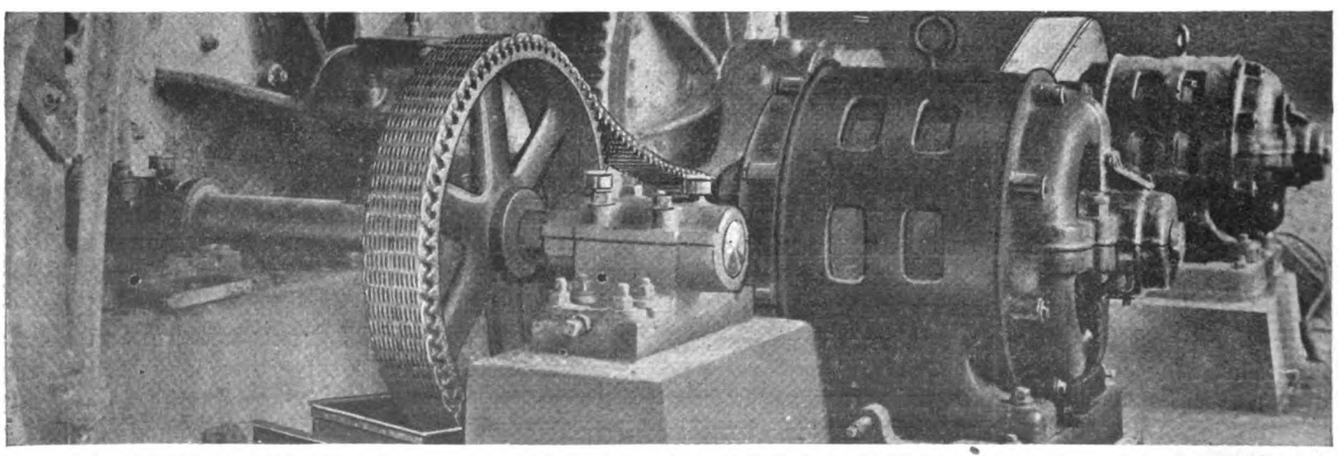
Link-Belt Silent Chain is the most commercially efficient and technically sound medium for the transmission of power. It is "Flexible as a Belt—Positive as a Gear—More Efficient Than Either."

The superiority of Link-Belt Silent Chain is proved by the vast number of drives in service today, after ten years and more of severe duty. They grow old in service because they possess lasting qualities. You should use Link-Belt Silent Chain on all important drives around the mine, such as compressors, fans, pumps, hoists, ball and tube mills, conveyors, etc.

Link-Belt Silent Chain is practically a flexible gear. It cannot slip. Tension is on the pulling side of the chain only; hence journal friction is much less than with belt drives. No power is lost due to bearing friction; 98.2% of the energy of the motor is transmitted to your shaft or machine to perform useful work. The drive is not affected by atmospheric conditions, operating equally well in hot, cold or damp places; it permits economy of space, because you are able to arrange for centers to suit the convenient location of your driving unit.

Enclosed in our oil-retaining dust-proof casing (running in oil) it is protected from dust, insures safety to workers, and requires practically no attention. It combines in one drive the best points of leather belts and cut gears, minus their disadvantages.

You can learn all about it by writing for 128-page price-list data-book No. 125. It contains information for every man interested in the economical transmission of power.



Two Link-Belt Silent Chain Drives Operating Ball Mills

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MORSE CHAIN COMPANY

ITHACA, NEW YORK

Write for Booklet—Address Nearest Office

Spring Sprocket

ATLANTA, GA.....Candler Bldg., Earl F. Scott & Co.
BALTIMORE, MD.....1402 Lexington Bldg.
BOSTON, MASS.....141 Milk St.
CHARLOTTE, N. C.....404 Commercial Bank Bldg.
CHICAGO, ILL.....Merchants L. & T. Bldg.
CLEVELAND, OHIO.....Engineers Bldg.
DETROIT, MICH.....1361 Abbott St.
KANSAS CITY, MO....Finance Bldg., Morse Engineering Co.
NEW YORK CITY.....30 Church St.
MINNEAPOLIS, MINN....So. 3rd St., Strong-Scott Mfg. Co.
MONTREAL.....St. Nicholas Bldg., Jones & Glassco Reg'd
PHILADELPHIA, PA.....Fuller Bldg.
PITTSBURGH, PA.....Westinghouse Bldg.
SAN FRANCISCO, CAL.....Monadnock Bldg.
ST. LOUIS MO.....Chemical Bldg., Morse Engineering Co.
TORONTO.....Bank of Hamilton Bldg., Jones & Glassco Reg'd
WINNIPEG, MAN.....Dufferin St., Strong-Scott Mfg. Co.

Shear Pin Sprocket

Product

Morse Silent Chains and Sprockets for the transmission of power for every purpose.

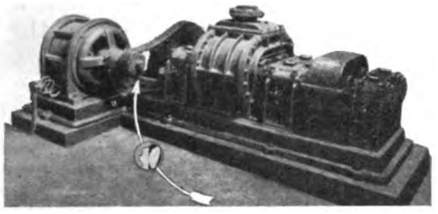
Illustrating Guide Link, Runs in Groove Around Sprocket, Holds Chain to Line, Prevents Swaying

General Description

The Morse Rocker Joint Silent Chain Drive is essentially a steel belt, made of flat links arranged to form teeth on one side of the chain which engage with teeth cut in the sprocket wheels over which it runs.

It is a gear belt and used in place of belting and gearing and made in varying pitches from ⅜ in. to 3 ins. to transmit from ¼ H. P. to 5,000 H. P.

In use today for over 3,500,000 H. P., giving positive speed ratios, increased production, short centers, better light, less maintenance, freedom from overhead construction.



25 H. P. Morse Silent Chain Driving Positive Blower in a Western Smelting Plant

The Morse Rocker Joint

The principal difference between "Morse" and all others is in that unseen but all-important part, the joint. Morse Drives are constructed with the fact in view—the joint bears the burden. Instead of a single pin, as in other joints, two special pins, both held in their respective halves, form the joint. No bushing is required.

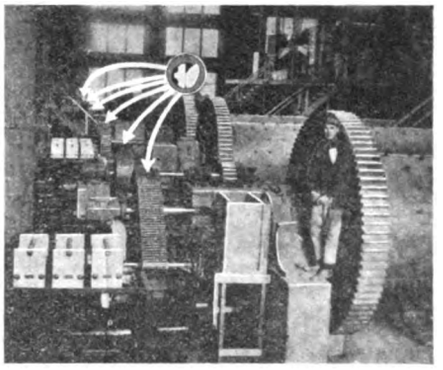
Note: When the chain is running straight, between sprockets, the flat of seat pin bears against one of the flat faces of rocker pin. As the chain bends in circling each sprocket, the curved side of one pin rocks upon the broad, flat side of the other, entirely eliminating destructive grinding friction.

Speed and Service

This exclusive "Rocker Joint" construction enables the Morse to run at a speed far in excess of other chains because lubricant is not essential to its operation; and after years of service (in every line of industry) it is accepted as the most durable chain on the market.

Material Parts

"Morse Drives" have great mechanical strength and are made with a large factor of safety, assuring 100 per cent. overloads. They need little attention, and consist of driving and driven sprockets (solid or split, s.s., and keyed) and silent chain belt. Driven sprockets are usually of cast iron. Driving sprockets of cast iron or steel as service requires.

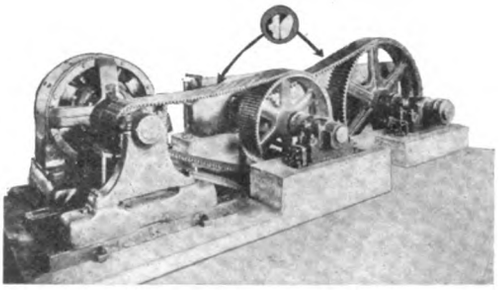


100 H. P. Morse Silent Chain Driving 5' x 20' Tube Mills

Advantages

Morse is accepted as the drive that is: positive as gears, flexible as a belt; unaffected by heat, cold, moisture or oil; durable, and gives long life and is especially desirable for service in Chemical and Metallurgical Works where dust, gases, acid fumes and steam ruin leather belting.

The world-wide demand and use in the most severe duty of Chemical Works, Smelters, Mines, and Mills is the evidence of their success.



80 H. P. Drive Sheet Lead Rolls. Drive Reverses Every 45 Seconds.

Morse Engineering Service

Send us your general layout and let our Sales Engineers design the drive to suit your special requirements. Engineering service and designs free. Address nearest office. Free bulletins for every industry.

See also our Current Advertising in "Mining Congress Journal"

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DODGE SALES & ENGINEERING CO.

Distributor of the Products of the

Dodge Manufacturing Corporation

MISHAWAKA, INDIANA

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Power Transmission Machinery

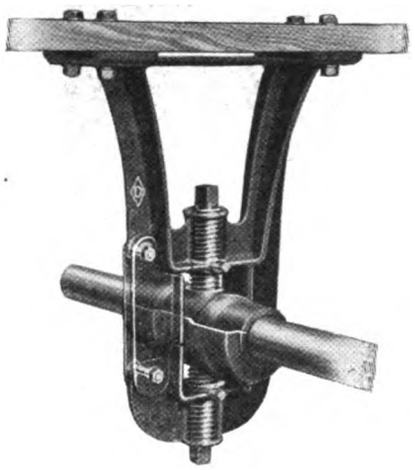
Products

Power Transmission Machinery.

For Elevating and Conveying Machinery see pages 650 and 651.

For Heavy Oil Engines see page 178.

For Dodge American System Rope Drives see page 212.

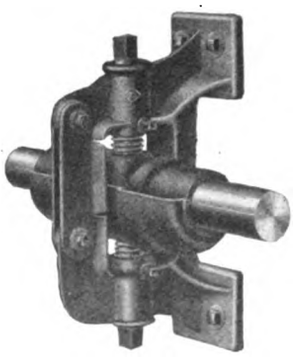


Dodge Ball and Socket Drop Hangers

The Dodge ball and socket shaft hanger combines proper distribution of strength with a true universal movement of the bearing in the frame, without permitting any rotative motion with shaft. They are suitable for the heaviest service.

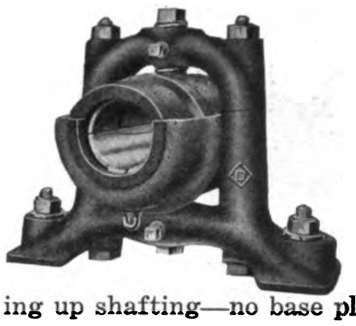
Dodge Ball and Socket Post Hangers

This hanger provides a true universal movement of the bearing in the frame and permits easy erection and alignment. It is strong enough to not only afford a rigid support for shaft but to minimize the constant vibration occasioned by rapidly revolving shafting, heavy angular pull of belts and sudden shock loads.



Dodge Heavy Head Drop Hanger

This hanger is of massive design and combines strength, finish and materials, adapting it to the most severe service.



Dodge Ball and Socket Adjustable Pillow Block

This pillow block offers the advantages of a ball and socket connection of the bearing in the frame and permits vertical adjustment, which is very desirable in lining up shafting—no base plates required.

Dodge Heavy Type Rigid Pillow Block

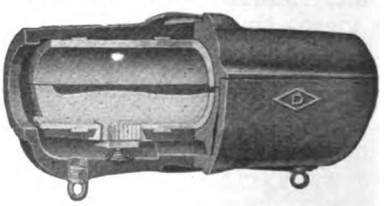
A pillow block of exceptionally massive construction made for unusually severe service such as encountered in stamp mills, etc., where heavy and violently fluctuating loads are encountered and where extraordinarily heavy wheels are carried on the shafts.

Dodge Rigid Pillow Block

A pillow block of heavy substantial construction—large bearing areas reduce friction—positive lubrication—oiling required but once every six months.

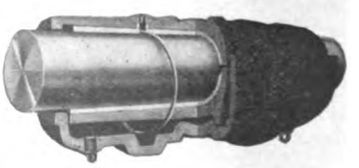
Dodge Capillary Self-Oiling Bearing

The infallible law of capillary attraction assures a constant, uniform and unbroken film of oil between the revolving shaft and bearing lining. Operation is automatic—no attention is required aside from draining off the old oil and refilling once in six months.



Dodge Ring Oiling Bearings

This bearing is of substantial construction and is positive in operation. Liberal oil reservoir requires filling but once every six months — large bearing areas reduce friction. The principle upon which this bearing is constructed has long been recognized as exceptionally efficient and satisfactory.



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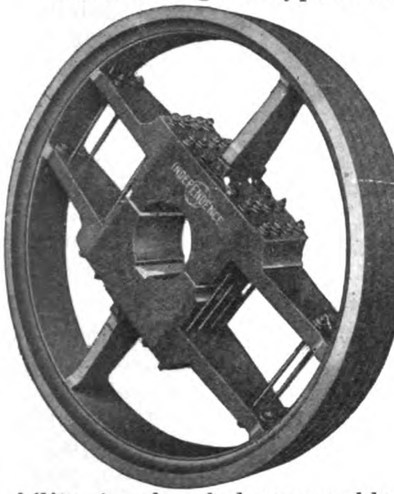
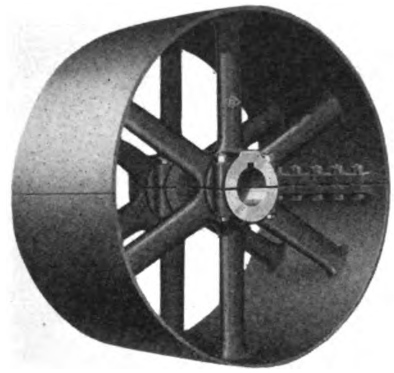
Dodge Wood Pulleys, Crusher Roll Type



The crushing roll type of Dodge Wood Split pulley is largely used on crushing rolls in concentrating plants where the service is such that metal pulleys cannot be used successfully. It is adapted for use in any place where a violently fluctuating or constantly recurring shock load is encountered. The important feature of this pulley is its resilience and consequent ability to absorb hammer blows and shock blows within its own structure.

Dodge Cast Iron Pulleys—Solid and Split

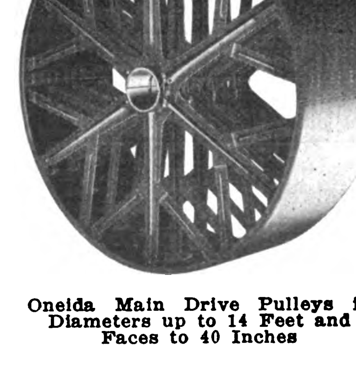


Dodge iron pulleys are machine moulded and can be furnished for single, double or triple belt service. Extensive equipment and long experience assures satisfaction and prompt delivery.

Oneida Steel Split Pulleys

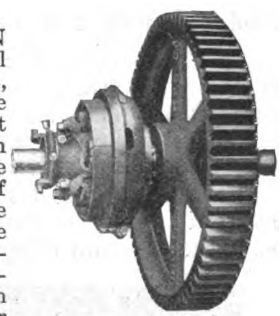
The Oneida Steel Split pulley combines lightness with great strength. The perfect oval crown affords greatest possible belt grip or adhesion—reduces bearing friction. Metals are countersunk, which prevents shearing strain on rivets. Double arms are provided beginning with 8-inch face in the smaller sizes and 10 and 12 inch face in the medium and larger sizes.

The arms as well as the hubs are made in two pieces. They are interwoven into the flanges of the hub and securely riveted into place. In sizes over 16 inches having 5-inch face and wider the arms are attached to rim with a special fish plate. This provides a broad solid bearing for the arms at the rim and gives double thickness at this connection besides permitting the use of more and larger rivets. These pulleys can be run safely at any speed at which it is practicable to operate a belt.

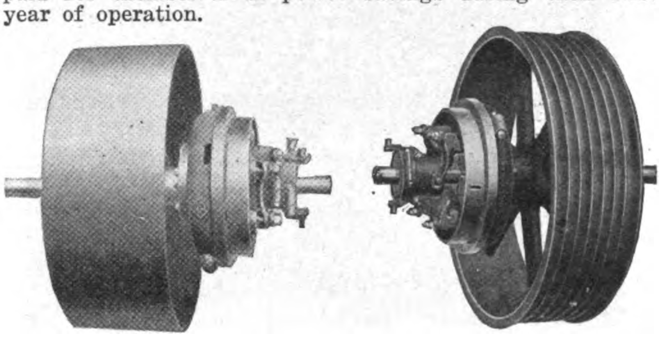


Oneida Main Drive Pulleys in Diameters up to 14 Feet and Faces to 40 Inches

Dodge Split Friction Clutches



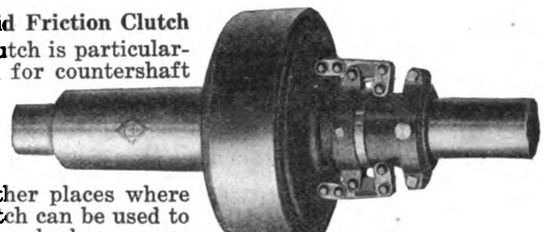
DODGE SPLIT FRICTION CLUTCHES permit the economical individualization of machines, groups or departments. They are built for all kinds of service, light and heavy, or for low or high speeds. The clutch is a separate and distinct mechanism in itself and not a part of the pulley, sheave or gear with which it is used. The construction is simple — adjustments can be quickly and conveniently made and renewal parts can be promptly obtained from our branches and agencies. Hundreds of these clutches have paid for themselves in power savings during their first year of operation.



RATED HORSE POWER CAPACITIES OF DODGE SPLIT CLUTCHES

Size of Clutch	Revolutions per Minute							Maximum Speeds		Maximum Bore
	100	150	200	250	300	350	400	C. I. Sleeves	Bab. Sleeves and Quills	
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.			
10	6	9	12	15	17	19	20	250	450	2½
12	10	15	20	25	28	31	34	250	440	3
14	15	22	30	37	47	51	51	250	430	3½
16	20	30	40	50	57	63	68	250	420	4½
18	25	37	50	62	71	79	85	250	410	5
20	32	48	64	80	91	100	109	250	400	6
22	40	60	80	100	114	126	...	250	390	6
24	50	75	100	125	142	157	...	250	380	6½
28	80	120	160	200	228	252	...	...	360	7
30	98	147	196	245	280	309	...	...	350	7½
36	128	192	256	320	365	...	...	...	325	8
42	174	261	348	435	495	...	...	...	300	10
48	242	363	484	605	...	...	...	...	275	10
54	340	510	680	850	...	...	...	...	250	12
60	480	720	960	...	...	...	...	...	225	12

Dodge Solid Friction Clutch



This clutch is particularly adapted for countershaft use and other places where a solid clutch can be used to advantage and where power requirements are within the range of capacities offered in this type of construction.

RATED CAPACITIES OF DODGE SOLID FRICTION CLUTCHES WHEN OPERATING AT SPEEDS SHOWN

Size of Clutch	Revolutions per Minute									Maximum Speed	Maximum Bore	
	100	150	200	250	300	350	400	450	500		Reg.	Spec.
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.			
4"	1¼	1⅞	2½	3⅛	3¼	4	4½	5	5½	600	1¼"	
5"	2	3	4	5	5¾	6½	7	8	9	580	1½"	
6"	3	4	6	7	8½	9	10	11	12	560	1¾"	
7"	4	6	8	10	11	12	13	15	16	540	2 "	
8"	5	7	10	12	14	15	17	18	19	520	2¼"	
9"	6	9	12	15	17	19	20	22	23	500	2½"	
10"	10	15	20	25	28	31	36	39	40	480	3 "	
12"	15	22	30	37	43	47	51	59	...	440	3 "	4"
14"	30	45	60	75	85	95	102	...	...	400	3"½	5"
16"	50	75	100	125	142	157	170	...	...	360	4½"	6"

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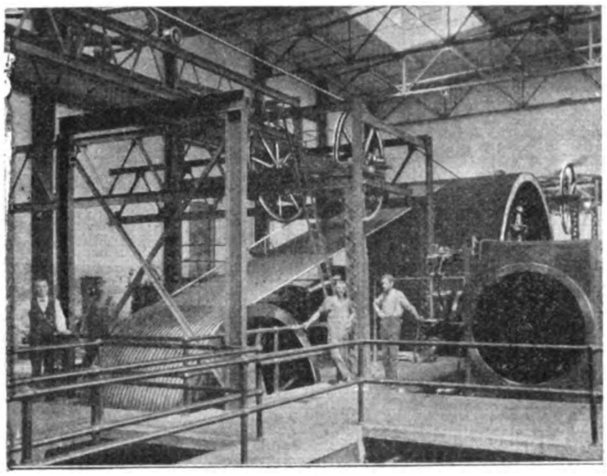
Dodge American System of Rope Driving

This system of rope driving is firmly established in its status as a power transmission medium of high efficiency, great economy, extreme flexibility and universal adaptability.

For engine drives and all the more important units of power distribution throughout a complete system of any magnitude, the rope drive is most satisfactory and efficient from every point of view.



One of Two Rope Drives of 1500 H. P. Each

The use of belts is distinctly limited to service of most ordinary character. The Dodge American system rope drive, however, is applicable not only to conditions of ordinary simplicity but also the requirements of the most diversified and complicated conditions.

Simple drives may be run at any inclination from vertical to level without variation of general form. This system is especially adaptable to vertical service. Direct delivery of power from one driving sheave to two or more driven wheels is readily arranged and is one of the valuable features of the American system.

Large reserve capacity is provided for carrying overloads, continuously or for short periods. While overloading is never desirable it is frequently necessary. An old overstrained belt on a large drive is liable to break and allow the engine to race and wreck the flywheel. The rope drive works at a low percentage of its ultimate strength and will consequently handle loads much beyond the conservative rating.

Sheave rim widths for the American system are 20 to 30 per cent. less than for the English system and 60 to 70 per cent. less than for belt pulleys of equivalent powers. The ability to arrange the rope drive in contracted space or to place it outside of a building is often a great advantage.

Distances of 150 to 200 feet may be spanned without intermediate supports and by the use of carrier idlers, long driving distances may be accommodated without serious loss of power.

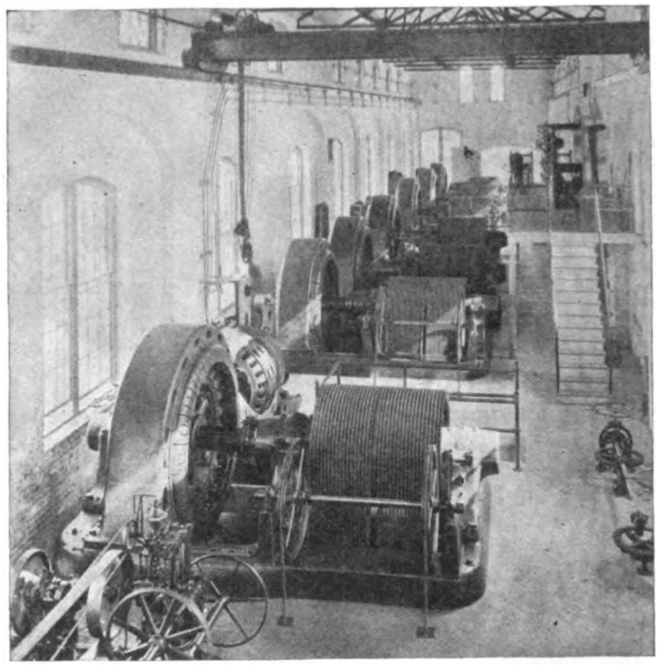
Power may be transmitted in any direction. Horizontal, inclined or vertical reaches are accommodated with equal ease.

Power may be transmitted at any angle—connecting shafts may be parallel or not—at or near the same lead or at different elevations. It is also possible to transmit power over, under and around obstructions.

One driving sheave may be connected with two or more driven shafts by separate drives or by a subdivided drive of the drop-off type. Subdivision of power distribution may be carried to any desired limits either when originally installed or at a later date. Alterations of distribution involve no change of main drives.

Rope drives may be arranged either indoors or out. Exposure to weather does not affect their operation. Delivery of power from one building to another may be accomplished by drives entirely outside, the connecting sheaves being mounted on shafts extending through the outer walls.

In addition to these advantages a Dodge rope drive will enable you to provide for future needs as well as present requirements. It is simply necessary to add additional grooves to the driving sheave. Power is transmitted without slippage—friction losses are reduced to a minimum, power distribution is steady and positive—first cost and maintenance low.



Eight Rope Driven Generators Aggregating 6600 K.W.

Our engineering department is qualified by long experience to offer recommendations for the economical and satisfactory solution of your power distribution problems.

HORSE POWER CAPACITIES OF DODGE AMERICAN SYSTEM OF ROPE TRANSMISSION

Horse Power of One Rope Based on an Arc of Contact of 180°

Diam. Rope	Rope Speed in Feet per Minute										
	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500
¾	1.5	3.0	4.5	5.8	7.1	8.1	9.0	9.7	10.2	10.4	10.3
⅞	2.1	4.1	6.1	8.0	9.7	11.3	12.6	13.7	14.5	15.1	15.2
1	2.7	5.4	8.0	10.5	12.8	14.9	16.8	18.4	19.7	20.6	21.1
1⅛	3.4	6.8	10.2	13.3	16.3	19.1	21.6	23.8	25.6	27.0	28.0
1¼	4.3	8.5	12.6	16.5	20.3	23.8	27.0	29.8	32.3	34.3	35.8
1⅜	5.2	10.2	15.2	20.0	24.6	29.0	33.0	36.6	39.7	42.4	44.6
1½	6.4	12.2	18.4	23.9	29.4	34.6	39.5	43.9	47.9	51.3	54.1
1¾	8.3	16.6	24.7	32.7	40.3	47.6	54.5	60.8	66.7	71.9	76.4

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THE MEDART COMPANY

FORMERLY MEDART PATENT PULLEY CO., INC.

Main Office and Works

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Engineering Sales Offices,
Chicago, Ill. Philadelphia, Pa.

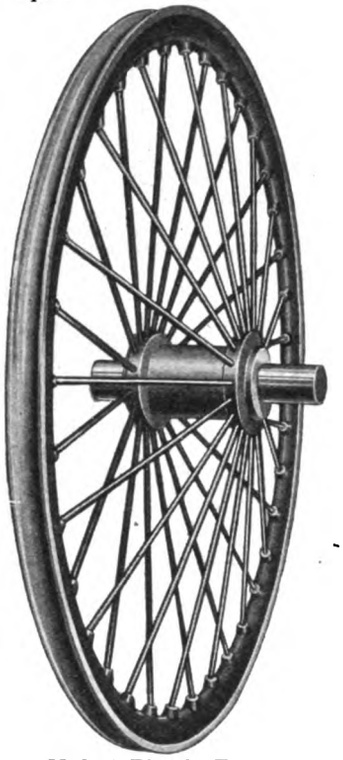
For 40 Years Manufacturing Engineers of Power Transmission Machinery

Products

Manufacturers of Turned and Polished Steel Shafting, Couplings, Collars, Hangers, Bearings, Bearing Supports, Friction Clutches, Belt Tighteners, Mule Stands, Steel Rim Pulleys, Cast Iron Pulleys, Wood Split Pulleys, Taper Cone Drums, Rope Sheaves and Complete Manila Rope Drives, Sprockets, Chain, Gearing of every description, etc. Catalog 43 and discount sheet sent on request.

Medart Bicycle Type Hoisting Sheaves

The principal merit of the Medart Bicycle Type Hoisting Sheave is in its ability to absorb violently fluctuating shock loads. The steel-spoke-spider, semi-steel-rim-and-hub combination construction gives a lighter weight sheave of greater strength than is possible to obtain in an ordinary cast-iron hoisting sheave. Shrinkage strains are eliminated in the "Medart" Sheaves; whereas in a plain cast-iron sheave the inherent, unavoidable shrinkage strains constitute an ever-present menace of breakage or failure when the sheaves are subjected to typical fluctuating mine-shaft loads.

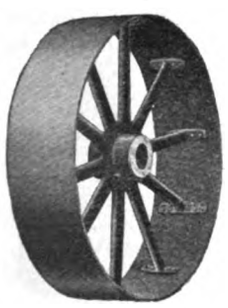


Medart Bicycle Type Hoisting Sheave

Medart Hoisting Sheaves are built and guaranteed to handle any load under any service conditions, in diameters up to 15 feet, in either solid or split construction. We can furnish Turned Steel Shafts (of our own manufacture) up to 6" diameter, or can supply Hammered Steel Shafts above 6" diameter, fitted to sheaves, making sheaves ready to install; also we can furnish Heavy Bearings, Bearing Supports, etc.

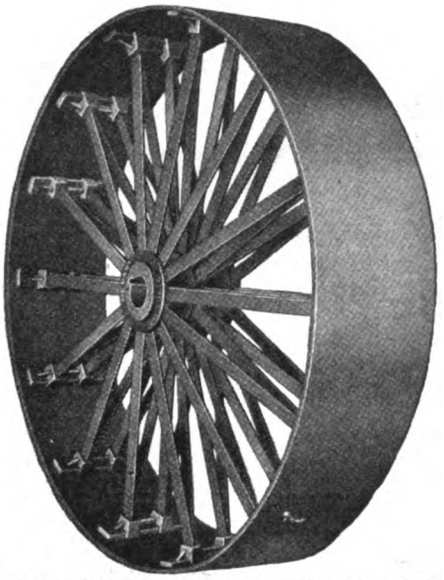
Medart Steel Rim Pulleys

The steel plate rim gives to this pulley a much greater tensile strength than the solid cast-iron pulley; the cast-iron spider, free from shrinkage strain, is of stiff construction, while the combination of steel rim and cast spider, accurately assembled, yields a rigid, true-running and well-balanced pulley, combining minimum weight and maximum strength. Exactness in construction rests on grinding both spider lugs and rim face to finished sizes. The steel plate rim gives a better face than it has been found possible to secure by grinding cast iron. The rim is rolled to a proper circle and riveted to the spider with pneumatic riveter.



Medart Solid Steel Rim Pulley

Medart Steel Rim Pulleys (made Solid, Split and Clamp Hub construction) for any belt service and speed, in sizes ranging from 8 inches to 16 feet diameter and 3 to 50 inches face width, combine minimum weight with maximum strength, being about 40 per cent. lighter than Cast Iron Pulleys for the same belt duty. They are warranted to meet our representations; should they fail to do so, replacement or refund will be made.



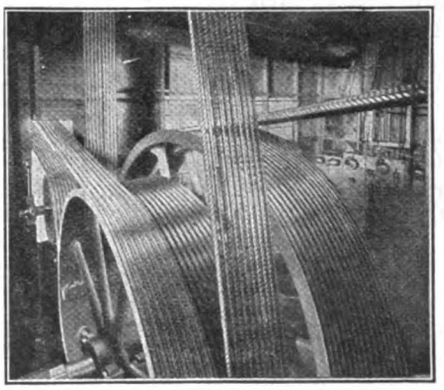
Medart "Hercules" Double Arm Solid Pulley

Medart "Hercules" All-Steel Heavy Duty Pulleys

This type Pulley, of special design and construction for handling the very heaviest and most violently fluctuating or shock loads, is made to suit specific service conditions in all sizes, solid or split construction, up to 15 feet in diameter and any face width up to 50 inches. We sell these pulleys on a rigid money-back guarantee basis. We can name dozens of the most important corporations that have experienced wonderful satisfaction in the use of these pulleys.

Medart Rope Drive Equipment—American or English Systems

During our 40 years' experience as designers and builders of Power Transmission Equipment to fit every conceivable kind of Power service conditions we have made hundreds of recomendations and built hundreds of complete Rope Driving Equipments for industries of widely diversified character.



Medart 500 H. P. Main Engine Rope Drive Installation

Practically every set of conditions favorable to the employment of an American System Rope Drive presents a problem peculiar to itself and requires careful handling by experienced engineers. Quotations and plans are made to meet the conditions of each installation.

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SMITH & SERRELL

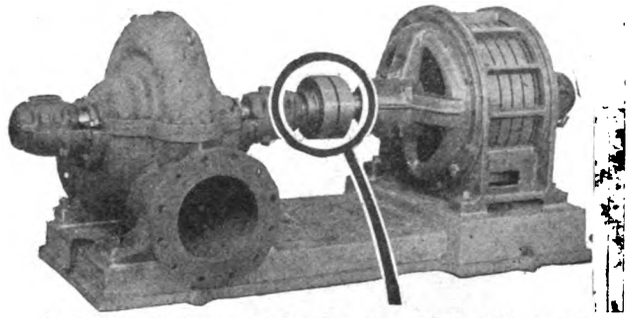
FRANCKE FLEXIBLE COUPLINGS FOR DIRECT-CONNECTED MACHINES

19 Halsey Street, NEWARK, N. J.

General Sales Agents

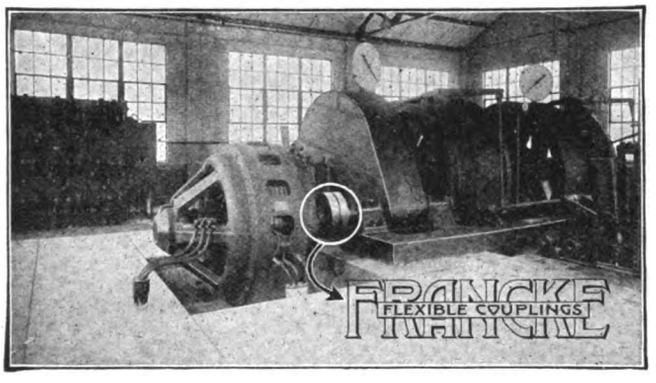
PINTITE RIGID COUPLINGS FOR LINE SHAFTING

In setting up centrifugal pumps, blowers, grinding machinery, etc., some error in shaft alignment is unavoidable. Further errors will result as operation proceeds due to uneven settling of foundations, heat expansion, vibratory movements, unequal wear of bearings, etc.



A typical motor-centrifugal pump drive with heavy bed-plate—carefully lined up and operated. Yet for satisfactory operation—"Francke" connected.

Francke Flexible Couplings protect the connected machines against excessive strains which would otherwise result from misalignment.



On reversing motor driven hoists, ball mills and other heavy machinery Francke Flexible Couplings have been delivering complete satisfaction for many years.

The Francke not only takes care of the unavoidable errors in lining up and provides for the errors sure to come with operation—it cushions shocks and vibrations. It also protects the connected machines from destructive strains which would otherwise result from excessive misalignment as caused by abuse or by an operating accident.

More than 3,000,000 H.P., over 28,000 installations in ten years, a very large proportion on the repeat orders of satisfied customers—that is the operating record of the Francke.

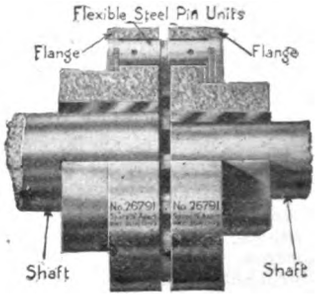
Size Selection

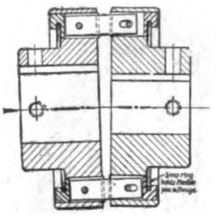
Correct size selection is important to obtain the best coupling and machine performance. The correct size is determined by normal and maximum peak H.P., R.P.M., both shaft sizes and the kinds of machines connected (both driver and the ultimate driven machines).

The coupling must be large enough for the largest shaft. It should have a rating in excess of the greatest overload capacity of the driver for smooth load conditions. For a pulsating load the coupling rating should be at least twice the maximum momentary capacity of the driver.

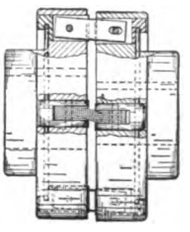
Pin Units Assembled As Used

Apart—To Show Construction





As each flexible pin unit is extensible, can pivot or rock on the cross pins, and the bundles of springs can bend between supports, so the coupling when assembled is flexible in all directions.



Details of "Francke" Construction and Movement. Flanges flexibly connected by laminated steel pin units.

In addition to the partial list of regular sizes given below we can quickly furnish other sizes. (The Double, Floating Ring Type Francke is recommended when excessive misalignment is expected.)

Size No.	Max. Bore	H.P. per 100 R.P.M.	Flange Dia.	Length Overall	List Price
325	7/8	2/3	3 1/4	3 3/4	$ 9.00
375	1 1/8	3/4	3 3/4	4	12.00
425	1 3/8	7/8	4 1/4	4 1/4	15.50
475	1 5/8	1 1/2	4 3/4	4 1/2	20.50
550	2	3	5	5	27.00
650	2 1/2	5	6 1/2	5 3/4	37.00
750	3	6	7 1/2	7	47.00
875	3 1/2	13 1/4	8 3/4	8 1/2	60.00
8 1/2	3	28	8 1/2	7 5/8	74.00
9 1/2	3 3/4	45	9 1/2	8 1/2	85.00
10	3 1/2	65	10	8 3/8	95.00
12	4 1/2	91	12	9 3/8	130.00
15	6	145	15	11 1/8	180.00
18	7 3/4	210	18	13 3/8	250.00
22	10	300	22	16 7/8	360.00
23	10 1/2	500	23	17	440.00
24	8	750	24	18 1/2	490.00
27	10	1000	27	22 1/2	580.00

On all inquiries and orders for Francke Flexible Couplings the following essential data should be supplied:

1. Number Required.
2. Horsepower (Normal and Maximum.)
3. Revolutions per minute.
4. Diameter of both bores.
5. Size of both keyways.
6. Kinds of Machines Connected (both driver and driven.)

Pintite Rigid Couplings for Line Shafts

A simple sleeve coupling with a positive grip. They are made in all standard line shaft sizes and in reduction patterns.

Catalogs

Separate bulletins describing various types of couplings, each for a specific purpose, will be sent on request.

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THE FALK CORPORATION

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Falk Herringbone Gears for Economy of Space and Power for All Classes of Mine Equipment

Partial List of Falk's Gear Products

Turbine Reduction Gears for Power House.

Herringbone Gears for Hoisting and Mining Machinery.

Herringbone Gears for Ore and Coal Machinery.

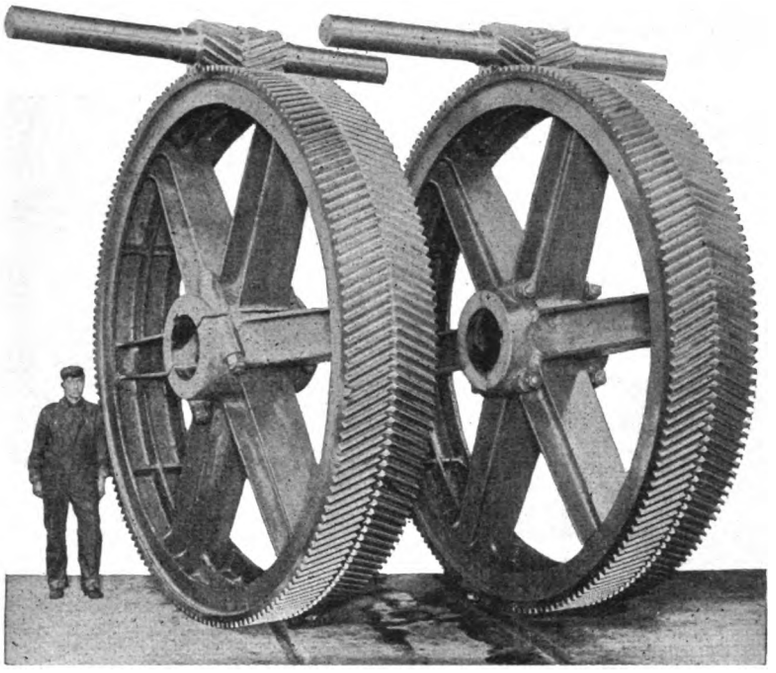
Herringbone Gears for Steel Works Equipment.

Standard Enclosed Reduction Gears — Single Reduction, Double Reduction, Two-Speed Reduction.

Turbine Reduction Gear Units—Single Reduction for Compound Turbine Drive; Double Reduction for Compound Turbine Drive.

Special Fly Wheel Gears for motor-driven air compressors.

Acid Open Hearth Steel Castings from 1 to 100,000 pounds.



Indispensable Equipment in the Electrification of Mine Hoists and Pumps

Falk Herringbone Gears

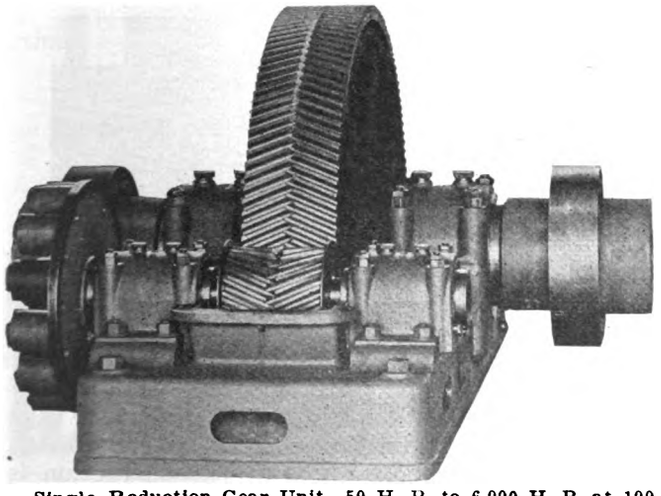
Falk Herringbone Gears, accurately hobbed from solid blanks, meet all requirements of the most exacting engineers for use in connection with mine hoists, pumps, compressors, tube mills and other mining plant equipment. They permit of simplified design combined with reduced power consumption, complete absence of shock and vibration and elimination of noise.

The stepped-tooth design, in addition to the theoretical advantages of the Herringbone principle, insures equalized wear of gear teeth—a factor which makes for a longer life of efficiency.

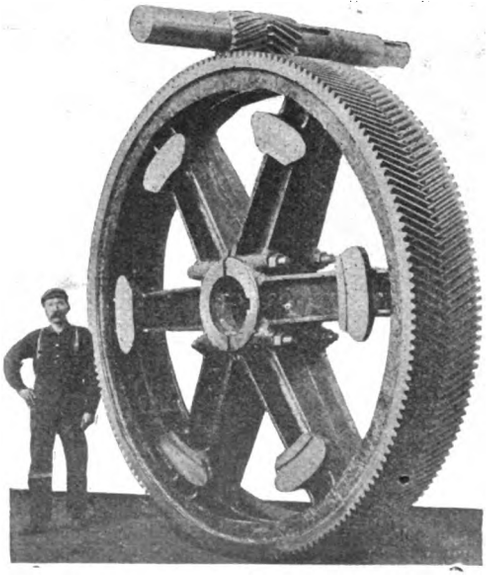
Falk Herringbone Gears permit the solution of virtually every gear problem with a single gear and pinion where double and triple trains were formerly necessary.

Gears from 2 inches in diameter to 16 feet—1¼ inch to 6 foot face—ratio as high as 20 to 1.

Our engineering department will help you solve your gearing problems. Write for further details.



Single Reduction Gear Unit—50 H. P. to 6,000 H. P. at 100 R.P.M. of Low Speed Shaft. Double Reduction Units from ¼ H. P. to 6 H. P. at 1 R.P.M. of Low Speed Shaft. Ratio from 50 to 1 to 100 to 1.



High Ratio Mine Hoist Gear with pads on arms for bolting to drum.

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FAWCUS MACHINE COMPANY

2820 Smallman Street, PITTSBURGH, PENNA.

Co-Manufacturers — BRANTFORD, ONT., CANADA, Dominion Steel Products Co.

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SAN FRANCISCO, CALF., K. W. Eichelberger
WILKES-BARRE, PA., Mining Equipment & Supply Co.

Manufacturers of

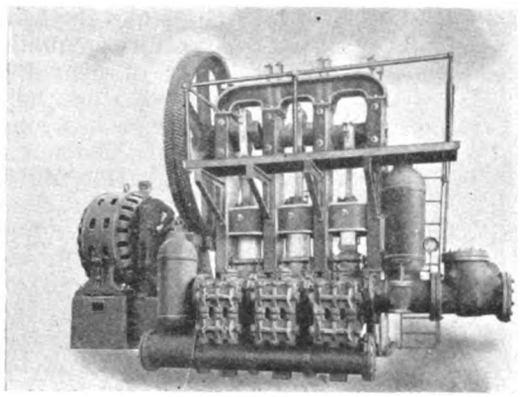
Cut Gears and Special Machinery

Products

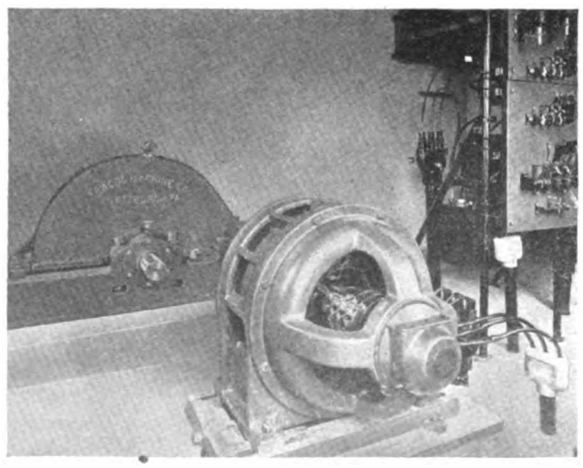
Fawcus Herringbone Gears
Fawcus Herringbone Gear Reductions
Fawcus Herringbone Turbine Transmissions
Fawcus Flexible Couplings
Rolling Mills; Special Machinery; Spurs; Bevels; Worms; Worm Wheels and Worm Gear Reductions.

Services

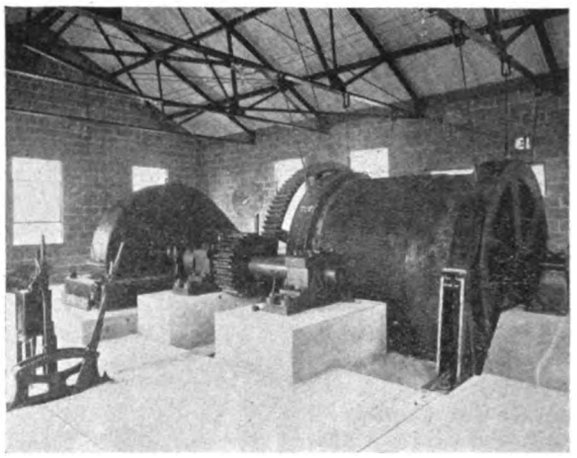
Our Engineers at all times will gladly advise, recommend and furnish estimates on your gear and machinery requirements.



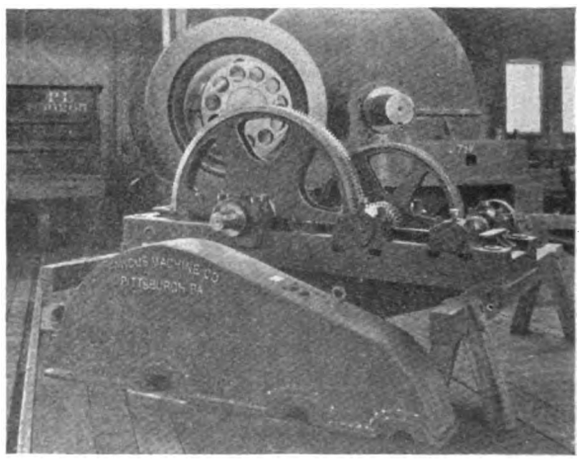
A triplex mine pump driven by a single reduction set of Fawcus Herringbone Gears, which impart uniform motion to the crank shaft of the pump, eliminate vibration, noise and backlash, with increased efficiency and longer wearing service in the pump and gears.



A Mine Fan 21 feet diameter requiring 50 H. P. at 68 R. P. M. coupled up through Fawcus Flexible Coupling to a Fawcus Herringbone Gear Drive. This method of application of electric drives to existing steam driven fans has been successfully used in numerous mines, is a great improvement over the belt drive and is considerably cheaper than a slow speed motor. It is more efficient, giving better and longer service than any other form of reduction. Fawcus couplings for connecting the fan eliminate and absorb the vibration in the fan, thus protecting the gear drive and motor.



A mine slope hoist coupled up to 600 H. P. Fawcus Herringbone Gear Reduction. The drive is used to electrify a former steam driven hoist. The motor is connected to the Herringbone Pinion of the reduction unit by a Fawcus Flexible Coupling and the gear shaft coupled by a solid flange coupling to the spur pinion shaft which was the crank shaft of the engine.



Fawcus Double Reduction Drive used for gold ore elevators, transmitting 20 H. P. at 900 to 8.25 R. P. M. about 109 to 1 ratio. This reduction is accomplished with overall efficiency of 97%. In these small drives roller bearings are used on the pinion shafts.

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Gears That Are Strongest at the Tooth Base Where Strength Is Needed

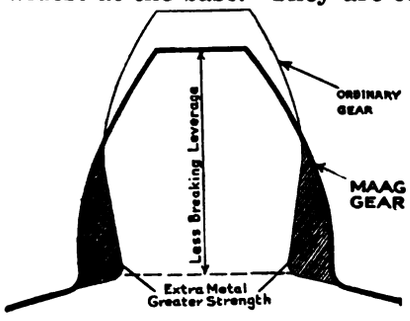
Products

Maag Cut Herrinbone Gears. Maag Cut Spur Gears. Maag Cut Helical Gears. Maag Cut Spiral Gears.

We also manufacture Machine Tools, Electric Traveling Cranes, Steam Hammers, Small Tools and Gages.

Greater Strength of Maag Tooth Form

All Maag Gears are cut with a tooth that is widest at the base. They are consequently strongest at the point where the strain is greatest and where the ordinary pinion is undercut and usually fails. Compare the tooth diagrams at the left, both taken from 12-tooth pinions,



one cut by the ordinary method, the other produced by the Maag system of gear cutting.

The shaded area which represents the extra metal in the Maag tooth, considerably increases its strength and similarly increases its margin of safety against sudden shocks and blows. Note that the Maag tooth is shorter, too. This does not reduce the working face, but merely decreases the breaking leverage on the base section.

Longer Active Profile Means Longer Life

In. Fig. 2 is shown graphically why Maag Gears are bound to outwear, to outlast and to run quieter

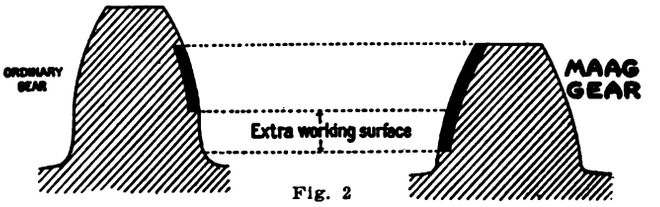
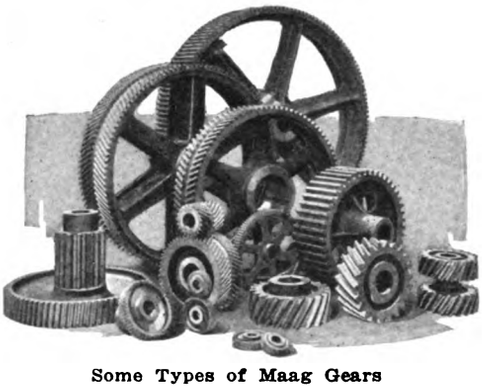


Fig. 2

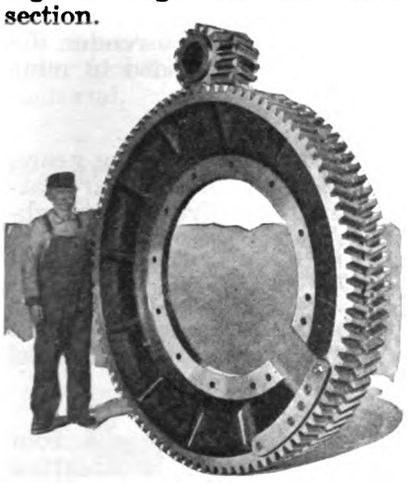
than ordinary gears. The difference in the amount of tooth face that actually does work—indicated by the solid section—is the reason for this.

Note that in the ordinary gear the wear is concentrated on a short portion of the face; grooves and ridges tend to form here and the wear is rapid and uneven. In contrast, the long, active profile of the Maag Gear distributes the wear evenly over practically the whole tooth face.

Wear is slow and uniform, the true tooth outlines are preserved and the original quietness of operation maintained throughout the life of the gear.



Some Types of Maag Gears

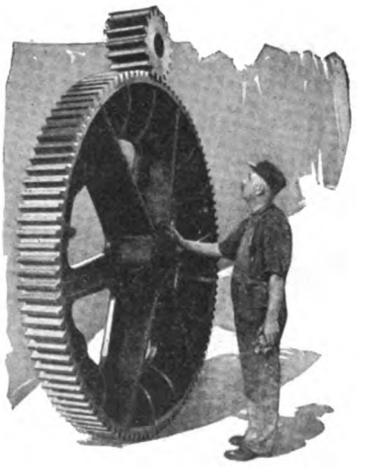


Large Gear Ratios Permit Compact Drives

Because we are able to cut Maag pinions with as few as eight teeth if necessary, without undercutting and without sacrificing strength or quietness, Maag Gears are specially suitable for mining machinery and installations where compactness of design is a prime essential.

Quiet and Smooth Running

The Maag gear tooth is so designed that the ratio of rolling to sliding contact is nearly three times greater than in the ordinary gear tooth. This results in proportionate reduction in noise and wear and a corresponding increase in life.



The Story of These Remarkable New Gears is Told in Catalogue No. 265. It is Worth a Careful Reading.

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R. D. NUTTALL COMPANY

PHILADELPHIA OFFICE
420 Land Title Building

PITTSBURGH, PA.

CHICAGO OFFICE
2133 Conway Building

All Westinghouse Electric & Mfg. Co. District Offices are Sales Representatives in the United States for Nuttall Electric Railway and Mine Haulage Products

Manufacturers of

Gears, Flexible Couplings and Trolleys

Products

Locomotive Gears—High grade cut-tooth gears for all makes and types of locomotives. Furnished either in spur type or helical type—treated or untreated.

Mine and Mill Machinery Gears and Reduction Gear Units—High grade cut-tooth gears and pinions for hoists, pumps, fans, compressors, conveyors, crushers, grinders, cranes, ball mills, tube mills, etc. Furnished in spur types or in helical types—treated or untreated. The illustration at the bottom shows a typical installation of Nuttall Reduction Gear Units. These Units can be furnished equipped with Nuttall Helical or Herringbone Gears.

Flexible Couplings—Furnished in three distinct types, A, B, and C, suitable for any condition and for any required horse power between 10 and 5000.

Trolley Equipment—Standard trolley equipment for any make of locomotive, including trolley poles, pole heads and harps, and trolley wheels.

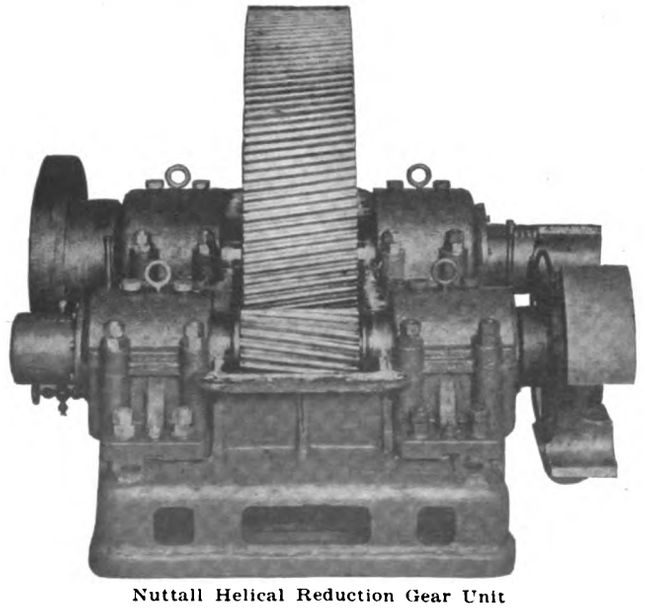
Helical Gearing—An important step toward lowering maintenance costs is the utilization of helical gearing wherever possible.

In this type of gearing the tooth comes into contact with its mate at the one side of the face, picking up the load gradually as the contact crawls across the face. In this manner, the impact resulting from a tooth suddenly taking up its load across the entire face, as in the case of the spur gear, is entirely eliminated.

The easing of a tooth into action and out of action, in this manner, reduces or entirely eliminates impact. The result is quiet and smooth load transmission.

Nuttall Helical Gearing is particularly suitable for hoists, pumps, fans, locomotives, compressors, etc.

Forged Steel Solid Locomotive Gear



Nuttall Helical Reduction Gear Unit

Heat Treated Gears

Forged Steel Gears in their natural state are too soft and coarse grained in structure to render the degree of service and economy demanded in mine operations.

In the Nuttall BP process of heat treating gears, the product, the chief constituents of which are carbon and iron, is so treated as to give both toughness and hardness.

The hardness of the teeth grades off slightly toward the center, producing a resistance to shocks and wear unequalled in any other carbon steel gears.

Nuttall BP Gears are guaranteed to give four times the life of untreated gears in identical service.

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THE TOOL STEEL GEAR & PINION CO.

CINCINNATI, OHIO

Huntington Supply & Equipment Co., Huntington, W. Va.
J. P. Biggert, Room 1310 Park Bldg., Pittsburgh, Pa.
J. T. Sudduth, Jr., Brown-Marx Bldg., Birmingham, Ala.
National Railway Appliance Co., 50 East 42nd St., New York.
Walter H. Evans, McCormick Bldg., Chicago, Ill.
Ambler & Riter, Kearns Bldg., Salt Lake City, Utah.

Products

"Tool Steel" Gears and Pinions for

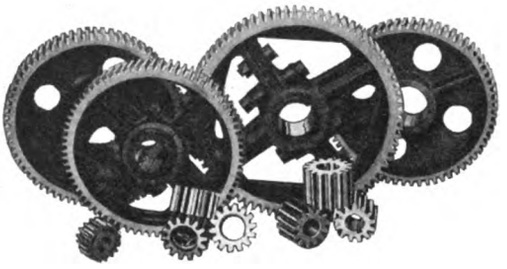
Mine Electric Locomotives.
Mining Machines.
Cranes and Hoists.
Conveyors, Crushers and Pulverizers.
All heavy duty gearing.

"Tool Steel" Crane Track Wheels and Conveyor Wheels.

"Tool Steel" Tooth Crusher Jaws and Segments.

"Tool Steel" Herringbone and Helical Gear Drives.

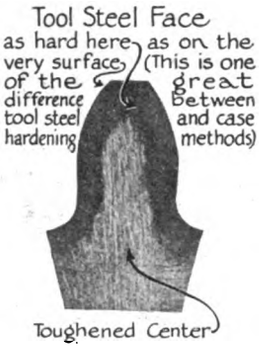
Typical Mining Parts

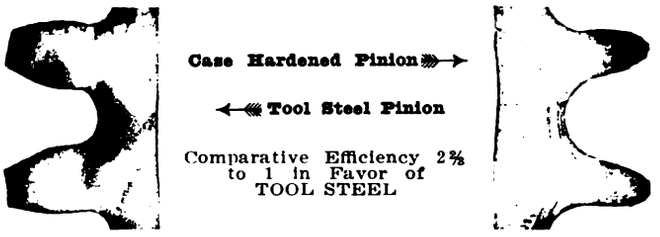


Split and Solid Locomotive Gears and Pinions

The "Tool Steel" wearing face takes on a brilliant polish and virtually eliminates friction.

The toughened center withstands all shocks and strains in severe service.

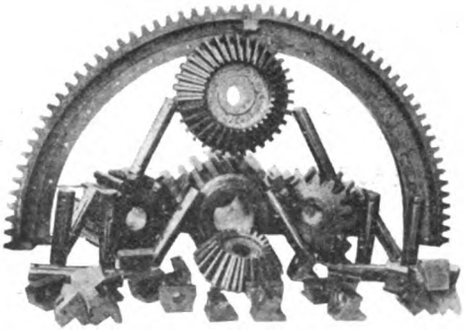




The above comparisons came from a test in identical service.

Increased Life of "Tool Steel" Gears

In repeated tests in the electric railway and mining industries, "Tool Steel" gears have given a life from five to eight times as great as that averaged from ordinary untreated steel, from three to six times as great as that of oil treated steel and from two to four times as great as case hardened material.



Mill Gearing, Gudgeons and Wearing Parts

Guarantee

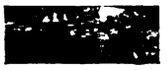
"Tool Steel" Gears and Pinions are positively guaranteed to outlast other grades in a ratio of

5 to 1 compared with untreated steel.
2 to 1 compared with Manganese steel.
2½ to 1 compared with mold hardened steel.

Coupling Boxes

Herringbone Mill Gears

Crane Wheels



Bevel Gears

Spur and Herringbone Mill Gears

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CLEVELAND WORM & GEAR CO.

CLEVELAND, OHIO

Cleveland WORM GEAR REDUCTION UNITS

Cleveland Worm Gear Reduction Units

Feature certain distinct and important advantages such as:

High efficiency;

Even torque, eliminating tendency to show effects of gear teeth in product;

Actual improvement in service based on the fact that while other gears wear out the worm gear wears in;

Greater compactness in lining up to other machinery due to right angle drive;

Enclosed dustproof housing;

Lower maintenance cost as result of design, construction, and perfect lubrication;

Less attention required—simply supply with oil and no other attention necessary;

Greatest silence—excels any other type of reduction unit in this respect—an advantage that grows on you;

Permits standardization of motor speeds;

Simplicity—Only two moving parts, the worm and the gear (exclusive of bearings).

They will be found to give satisfactory service in connection with the following machinery:

Mines—Certain styles of Heavy Duty Pumps; Heavy Doors for Ventilation Duty.

Mills—Elevator and Conveyor Head-shafts; Agitators; Drag Conveyors; Mechanical Filters; Ore Feeders.

Cement & Lime Plants—Screw Conveyors; Cement and Lime Kilns (rotary); Elevators; Tramways and Cableways.

Power Plant—Mechanical Stokers; Ash Conveyors and Elevators.

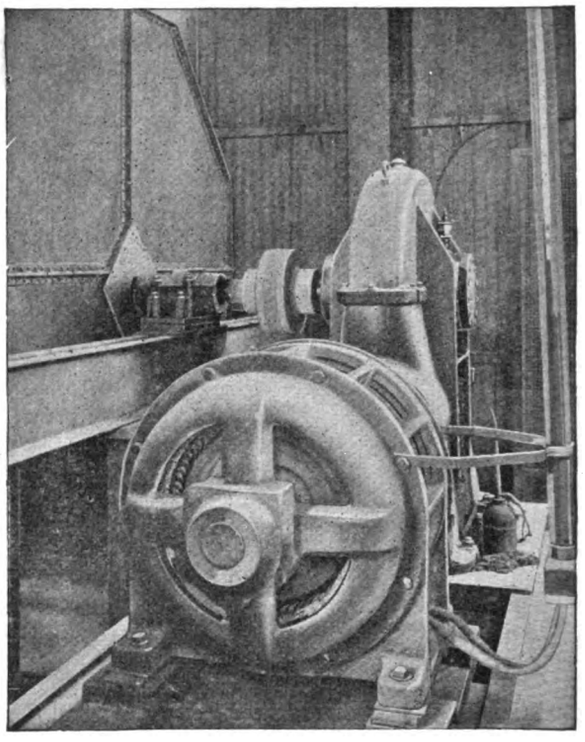
Smelters & Refineries—Sintering Machines of the endless belt type; Mechanism for tilting furnaces and converters; Elevating Machinery for heavy material; Tilting Furnaces; Mechanical Roasting Furnaces; Nodulizing Kilns.

Miscellaneous — Pumps; Concentrating Tables; Conveyors—Pan, Belt, Bucket, Spiral; Dorr Thickeners; Dryers; Kilns; Coolers; Fans; Agitators.

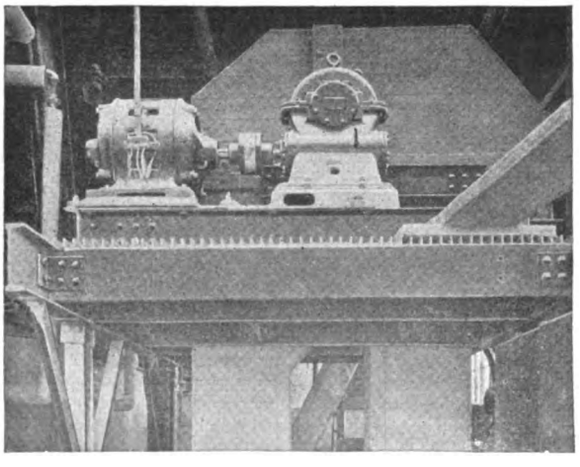
Cleveland Worm Gear Reduction Units are made in sizes for use with motors from 1 to 400 H. P. and handle abnormal gear ratios with ease.

Our Engineering Department will gladly cooperate with yours.

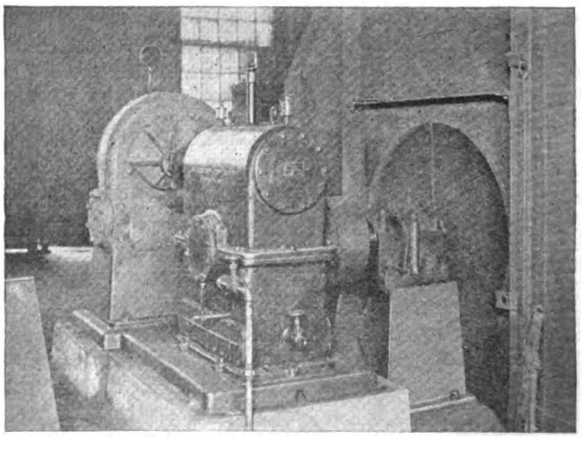
Write for latest bulletin giving full information.



Cleveland Worm Gear Reduction Unit applied to Belt Conveyor. Motor 75 H. P. 480 R. P. M. Ratio in worm drive 16-1.



Cleveland Worm Gear Reduction Unit applied to Bucket Elevator. Motor 10 H. P. 725 R. P. M. Ratio in worm drive 17½-1.



Cleveland Worm Gear Reduction Unit applied to Forced Draft Fan and Stroker Drive. Turbine 125 H. P. at 3200 R. P. M. Reduction in worm drive 10¾-1.

"AMERICA'S WORM GEAR SPECIALISTS"

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THE FALK CORPORATION

MILWAUKEE, WISCONSIN

Agents and Branch Offices

PITTSBURGH
W. O. Beyer, 1007 Park Bldg., Pittsburgh, Pa.

NEW YORK AND NEW ENGLAND
M. P. Fillingham, 50 Church St,, New York City

WEST COAST
F. W. Grimwood, Rialto Bldg., San Francisco, Cal.

PENNSYLVANIA COAL FIELDS
Vulcan Iron Works, Wilkes-Barre, Pa.

COLORADO DISTRICT
Denver Engineering Works Co., Denver, Colo.

FOREIGN REPRESENTATIVE
Gustav Melms, 3 Rue Taitbout, Paris

Canadian Representative: Engineering Equipment Company, Ltd., 619-623 New Birks Bldg., Montreal, Canada

Falk Herringbone Gears for Economy of Space and Power for All Classes of Mine Equipment

Partial List of Falk's Gear Products

Turbine Reduction Gears for Power House.

Herringbone Gears for Hoisting and Mining Machinery.

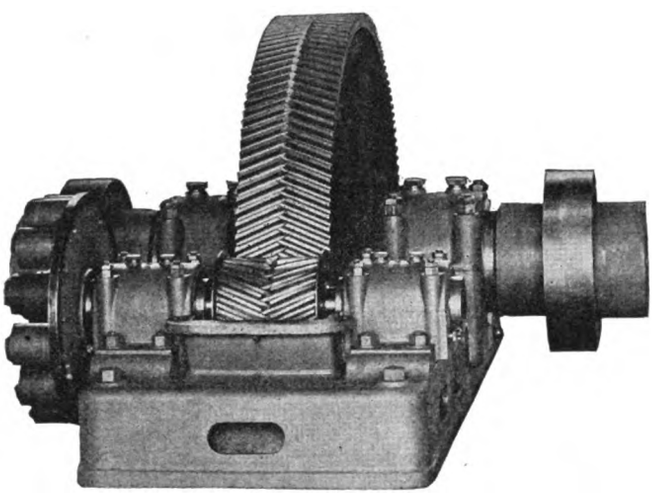
Herringbone Gears for Coal and Ore Machinery.

Herringbone Gears for Steel Works Equipment.

Standard Enclosed Reduction Gears—Single Reduction, Double Reduction, Two Speed Reduction.

Turbine Reduction Gear Units—Single Reduction for Compound Turbine Drive; Double Reduction for Compound Turbine Drive.

Acid Open Hearth Steel Castings for all purposes from 1 to 100,000 pounds.



Single Reduction Gear Unit—50 H. P. to 6000 H. P. at 100 R.P.M. of Low Speed Shaft.

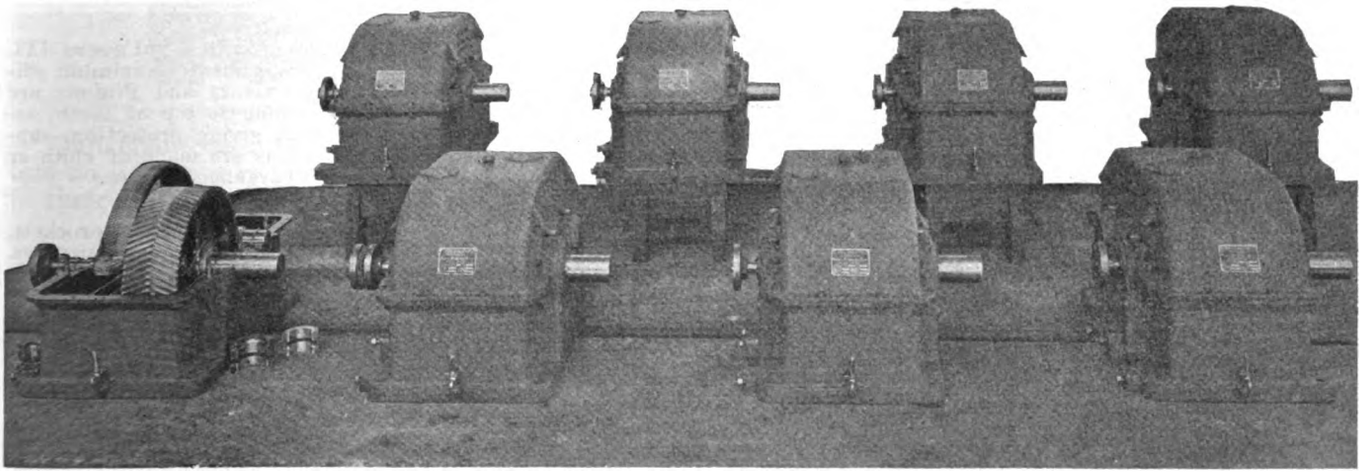
Falk Herringbone Gears

Falk Herringbone Gears are accurately hobbed from solid blanks. They retain, in practical operation, all the theoretical advantages of the herringbone principle, and in addition the **stepped tooth design** insures **equalized** wear of the gear teeth—a very important factor.

Falk Herringbone Gears permit the solution of virtually every gear problem with a single gear and pinion, where single and triple trains were formerly necessary.

Gears from 2 inches to 16 feet in diameter, from 1¼ inches to 6 foot face, ratio as high as 20 to 1.

Let our engineering department assist you in solving your power transmission problems.



Group of Double Reduction Gears

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FOOTE BROS. GEAR & MACHINE CO.

213-223 No. Curtis Street, CHICAGO, ILLINOIS, U. S. A.

IXL Gears of All Kinds for All Purposes; Speed Transformers

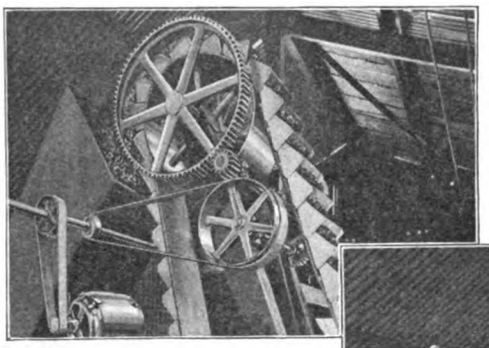
Products

Gears and Pinions—Mitre, Bevel and Spur; Gears—Noiseless, Rawhide, Herringbone; Sprockets; Flexible Couplings; Speed Transformers; Tractor Transmissions; Racks; Special Machinery To Order.

Foote IXL Speed Reducers

The use of Foote IXL Spur Gear and Worm Gear Speed Reducers is the ideal method of reducing the speed of motors running elevator legs, belt, bucket and screw conveyors of all types, grinders, mixers, agitators, hoists, etc.—wherever a reduction of 3 to 1 to 500 to 1 is required.

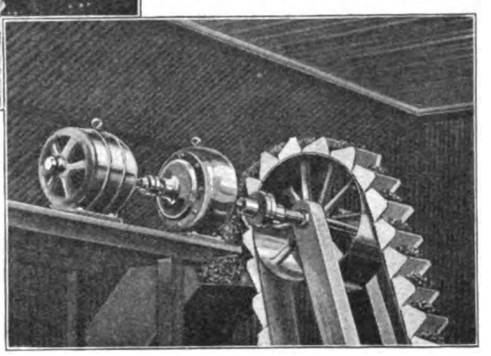
With it, high speed motors can be used where low speed motors are ordinarily required. Installation cost is low. Maintenance is practically nothing. They require practically no attention and give long, dependable service. They deliver more of the motor power than other types of drives. They are trouble-proof and safeguard your workers.

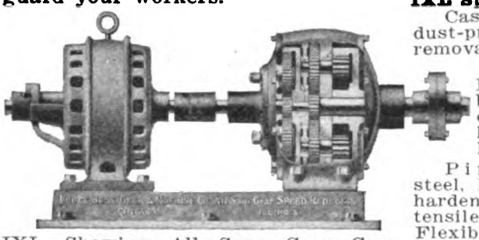


The above illustration shows a costly and space-wasting method of reducing speed of motor running bucket conveyor. A low speed motor is used in connection with belts, shafting pulleys and four open gears to accomplish the necessary reduction. This open equipment quickly wears out and is expensive for initial installation as well as up-keep.

See method illustrated at right.

The illustration below shows the most modern and efficient method of reducing electric motor speed. A high speed motor is used, as high speed motors cost less than low speed motors. The motor is direct connected to a Foote Spur Gear Speed Reducer, which gives the necessary reduction of speed. Note that the Speed Reducer is compact and all gears run in oil. It delivers more power, has long life, costs practically nothing for maintenance. It saves money.





IXL—Showing All Spur Gear Construction (Non-Planetary)

IXL Spur Gear Reducer

Case — Cast iron, dust-proof, oil tight, removable covers.

Bearings—Phosphor bronze, bushed throughout; designed for heavy duty and long life.

Pinions — Alloy steel, heat treated and hardened, giving great tensile strength. IXL Flexible Coupling can be furnished to compensate any reasonable error in alignment of motor and transformer shafts.

Design—The IXL Transformer is constructed along lines of a motor. Cast iron base furnished according to your blue prints at additional cost.

Quality—Designed and built to give perfect satisfaction.

Prices—On application. Send for full information.

IXL Worm Gear Reducer

Case—Cast iron, sand blasted inside and coated with oil-proof preparation, oil-tight and dust-proof.

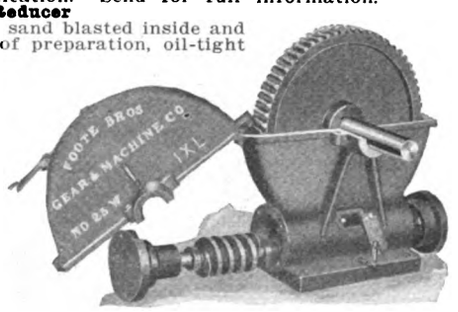
Worm — Made of steel.

Worm Gear—Made of bronze or semi-steel.

Worm Shaft—Properly babbitted so worm and gear run freely.

Oil System — Ample space for properly oiling high speed worm shaft.

Bearings — Large, providing for long life. Hyatt Roller Radial Bearings furnished at extra cost.



IXL—Showing Enclosed Worm Gear

Look-in Doors—Providing for easy inspection of gear and worm. Worm and shaft and upper cover easily removable. Workmanship guaranteed.

Prices—On application. Send for full information.

IXL Flexible Coupling

Where shafts are run at a slight angle to each other or where they are slightly off center, these couplings will prevent hot boxes and strains to shafts and bearings. Made in dimensions to replace any standard coupling. Will give long dependable service.

Foote IXL Cut Gears. Heavy Duty Hardened Gears.

We manufacture every type of heavy duty hardened gear for all purposes. Treated by special heat treatment process, which gives them four times the actual strength of cast iron gears of equal size. Wearing qualities are 25 to 1 in comparison to soft steel and iron gears.

Miter and Bevel Gears

IXL Miter, Angle and Bevel Gears are cut with the finest accuracy, thus insuring smoothness and quiet running.

Worm Gears

We can furnish Worm Gear Drives of any style and material desired. Our Engineering Department will assist you in the solution of your transmission problems.

Spiral Gears

IXL Spiral Gears can be supplied in any size for any purpose—made of materials to suit your special requirements.

Spur Gears

Cut Spur Gears, all sizes up to 144 inches in diameter. Made from high grade steel forgings, castings, or the very best grade of cast iron.

Internal Gears

IXL Internal Gears of every description, either plate back or plain rings. All pitches up to 4-diameter pitch are generated on Fellows Gear Shaper; 3-diameter pitch and coarser, have planed teeth of great strength. Especially adapted for hoisting, mining and rolling mill machinery.

Rawhide, Bakelite and Cloth Pinions

For high speed drive in connection with metal gears, IXL Bakelite or rawhide noiseless pinions insure maximum efficiency, elasticity and durability. Gears and Pinions are made up with brass flanges, reaching to top of teeth, securely riveted and bolted together, giving protection, support and long life. Bakelite Pinions are made of cloth or cotton fabric, compressed under hydraulic pressure.

Sprockets

Block, Roller, silent or any other style of chain sprockets, supplied in any material and any quantity for all purposes.

Racks

We can furnish IXL machine racks in almost any size blank and pitch and in continuous section of any length that can be conveniently shipped.

Literature

Send for catalogs on speed transformers, gear data book, special information, prices, etc.

Engineering Service

Our Engineers will be pleased to assist you in any problems relative to gears, speed transformers, tractor transmissions or special machinery. Submit your blue prints.

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WILLIAM GANSCHOW COMPANY

1001 West Washington Boulevard, CHICAGO, ILL.
Telephone: Monroe 4561

Manufacturers of Cut Gears

Products

Ganschow A.B.C. Spur Gear and Worm Gear Speed Reducers, Direct, Right Angle and Vertical, Tractor and Automobile Gears; Spur, Bevel, Mitre and Spiral Gears; Hardened Gears.

Also manufacturrs of Rawhide and Bakelite Noiseless Pinions.

Ganschow A.B.C. Spur Speed Reducers

In Ganschow Speed Reducers, every principle of construction which makes for better work, at less maintenance expense, has been incorporated.

Ganschow Spur Gear Speed Reducer

Ganschow Speed Reducers are simple; they contain no unnecessary parts which would tend to add to their initial expense or operation.

They are compact; the design is such that the few moving parts require but little space to work in.

They are strong; planetary overhand is well balanced, and supported by a newly patented device. Strength is brought about by a well-ribbed body, gears of hardened nickel steel, and studs and shafts also made of nickel steel ground to size.

They are economical; connect them direct with high speed motors, and they will run on and on, demanding no attention other than an occasional supply of oil, which is uniformly distributed throughout the gearing by the splash system.

Ganschow Speed Reducers are dust-proof and fool-proof.

They are made for reductions from 4-to-1 up to 250-to-1.

Literature

Send for complete data and information on Ganschow A.B.C. and Compound Spur Gear Speed Reducers.

Engineering Service

Our engineers will work out your speed reducing problems and recommend the very best drive for the particular purpose you may have in view by giving us the following information:

Horse power, speed of motor and ratio wanted, or speed of driven shaft.

Class of work the Transformer will be used for.

Continuous or intermittent service.

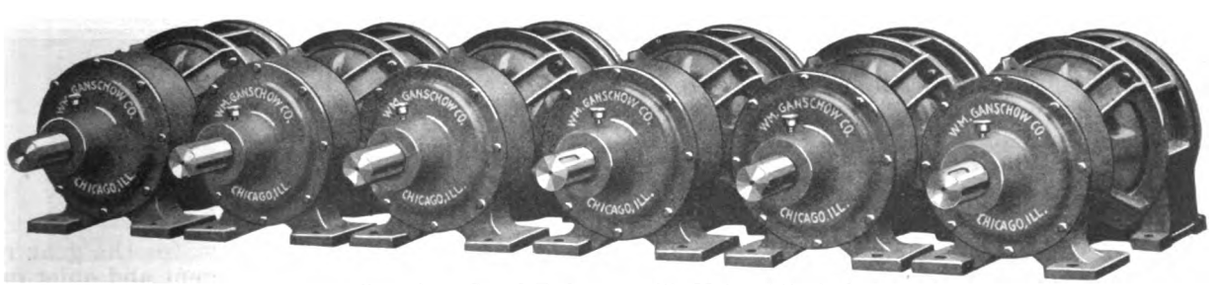
Load—uniform, apex, or subject to shock.

All of our Transformers are for direct connections with Flexible or Universal Couplings; if required otherwise, we must be informed, so that we can provide extra length of shafts for outboard bearings.

Worm Gear

Worm Gears

In any style or material desired. The best combination of materials is used to suit the requirements of each case.



Ganschow Speed Reducers with Motor Attached

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The Poole Engineering & Machine Co.

WOODBERRY, BALTIMORE, MD.

Manufacturers of

Gears and Power Transmission Machinery

Since 1843

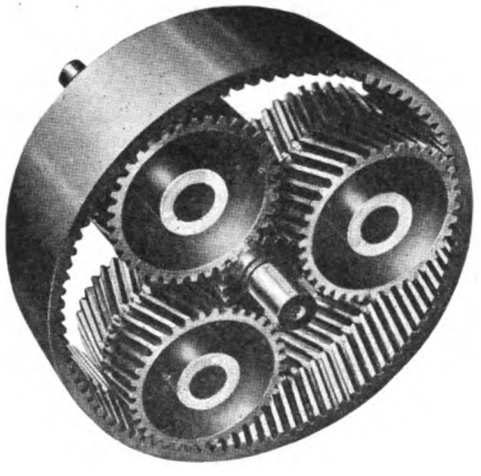
The TURBO-GEAR is patented, self-contained, mechanical power transmission interposed between and coupled directly to the prime mover and the driven unit for the purpose of stepping up or stepping down speeds.

Application

Speed, efficiency and safety are the watch-words of the day. The Internal Herringbone TURBO-GEAR meets all these requirements. It can be successfully employed for all kinds of gear drives, replacing the noisy, inefficient and highly dangerous methods of transmitting power through belts, ropes and chains.

TURBO-GEARS are used with:

Compressors;	Oil Engines;
Fans;	Pumps;
Gas Engines;	Steam Engines;
Line Shaft Drives;	Steam Turbines;
Mechanical Stokers;	Motor Drives.



Gear Members

Motor Drive

The combination of a high speed motor drive with a high-ratio TURBO-GEAR gives a higher overall efficiency and lower power cost than can be obtained by any other form of transmission whether direct or indirect.

Turbine Drive

Steam Turbines to be economical must run at high speeds. Many machines, such as centrifugal pumps, fans, generators, etc., which would lend themselves admirably to this type of prime mover, require much lower speeds than that of the turbine for their best efficiency. The TURBO-GEAR correctly solves the problem of permitting each unit to run at its most efficient speed.

Engine Drive

In the case of steam, gas or oil engines, it is sometimes necessary to have higher speeds to secure the best efficiency for the driven unit. The TURBO-GEAR is equally efficient in this case.

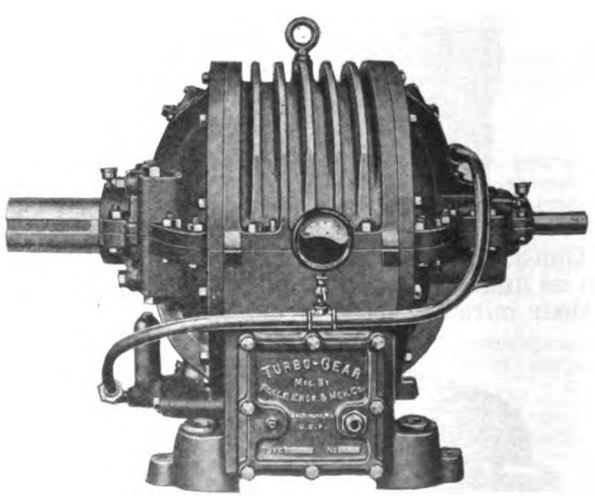
Gear Members

The TURBO-GEAR consists of a large, internal, double-helical gear, made of a special analysis, heat-treated steel forging, a double-helical pinion, cut integral with the high-speed shaft and made of heat-treated chrome-vanadium steel, and intermediate gears made of high carbon steel forgings.

The intermediate gears are mounted on hardened and ground forged steel shafts with large bronze bearings and secured to the cast steel slow-speed member. On this slow-speed member, which is a part of the slow-speed shaft, are mounted two heavy-duty ball bearings, one on each side of the gears, and supported directly by the substantial housing. Thus it will be seen that the slow-speed member and shaft carrying the intermediate gears, and the high-speed shaft and pinion are independent of one another for support and yet each is supported directly by the housing. The internal gear is stationary, the moving members are the pinion and the intermediate (planetary) gears.

Housing

The housing is made of tough grey cast iron horizontally split, in accordance with the most approved practice, affording perfect accessibility to all parts. It is extremely substantial and well



Standard Turbo Gear

ribbed to afford a rigid support for the gear members, which is essential to efficient and quiet opera-

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tion. The high and low-speed bearings are provided with special sealing boxes, positively protecting them from the intrusion of grit and dust.

Range of Speed Reduction

The large ratios possible with the TURBO-GEAR permit a greater speed reduction than on any other type of single reduction gear. The ratios obtainable with standard TURBO-GEARS range between 3:1 and 15:1.

Efficiency

The efficiency of the TURBO-GEAR is shown by accurate tests to be 98 to 99 per cent.

Safety

The totally enclosed feature combined with the total absence of pulleys, belts, chains, sprockets and exposed gears, makes it impossible for the workman to get his fingers or clothing caught in any part of the TURBO-GEAR.

Capacity

The TURBO-GEAR can be furnished for any capacity up to 1500 H. P., depending on the speed and ratio of reduction required.

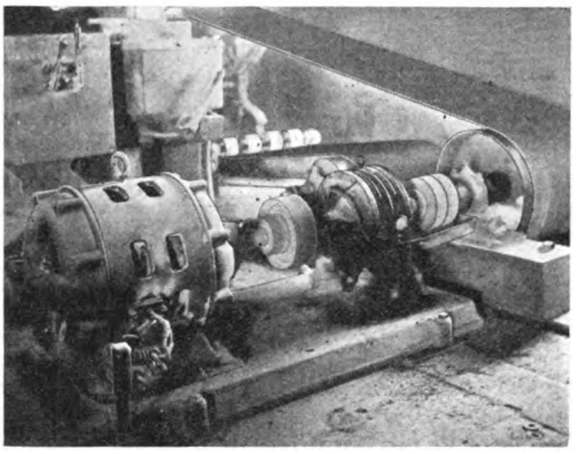
Reversibility

The TURBO-GEAR will drive in either direction of rotation without making any changes in it whatever. It will also step up or step down the speed. The high and low-speed shafts rotate in the same direction.

Lubrication

The high-speed shaft has a central passage through which the oil is pumped, and continuous streams of oil are sprayed on the gears through radial passages in the pinion.

The oil, after lubricating the bearings and gears, is immediately drained to the main oil reservoir in the base of the housing. Here it is filtered, cooled and returned to the pump to be used over again.



Turbo Gear-Motor Drive to Belt Conveyor

Economies and Advantages of the TURBO-GEAR

In addition to the features of the TURBO-GEAR already enumerated are the following:

Low first cost (lower than a complete gear, chain or belt drive).

Low maintenance cost (practically nothing).

Low erection costs.

Freedom from noise and vibration.

Small floor space required.

Totally enclosed (can be used in wet, dirty, dusty, gritty places).

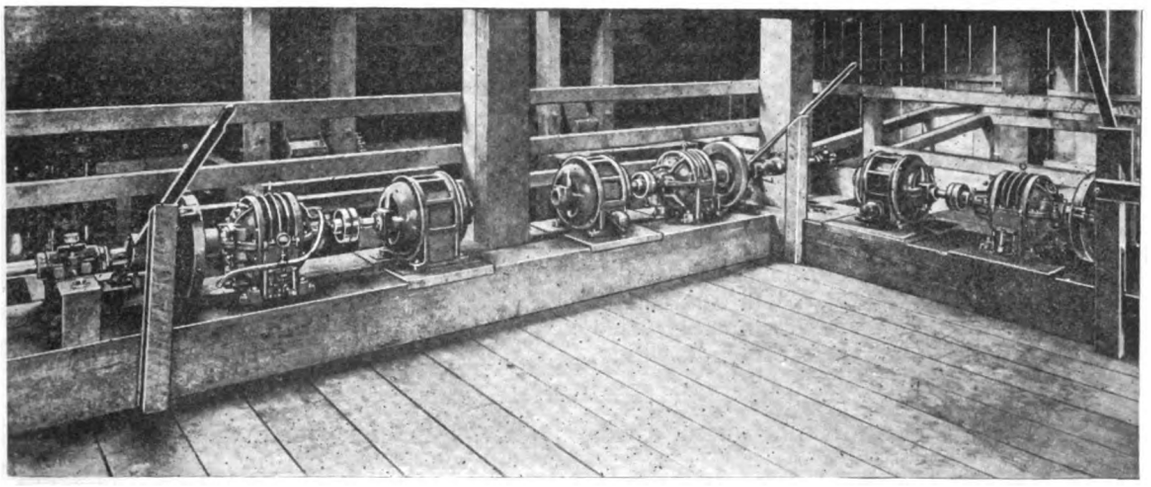
No side strain on shafts or bearings (pure torque transmission).

High and low speed shafts in axial alignment.

Three times as many teeth in constant contact as on any other form of herringbone gear drive for equal power; consequently, low tooth pressure with corresponding increase of life.

Cool operation—sure proof of high efficiency.

When writing for quotations and further information regarding TURBO GEARS, give service, horsepower to be transmitted and speeds of driving and driven units.



Motor With Turbo Gear Reduction Driving Elmore Washers

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W. A. Jones Foundry & Machine Company

Main Office and Factories

4432 West Roosevelt Road, CHICAGO, ILL.

Branch Sales and Engineering Offices

NEW YORK, N. Y.....26 Murray Street
PITTSBURGH, PA.....Union Arcade
MILWAUKEE, WIS..First Wisconsin National Bank Bldg.
BUFFALO, N. Y.....184 Main Street

Stock Carried at New York City and Buffalo Branches and by Dealers in All Important Distributing Centers

Speed Reducers and General Power Transmitting Machinery

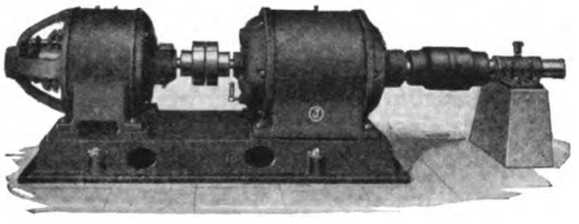
Products and Services

Spur Gear Speed Reducers; Enclosed Worm Gear Drives; Friction Clutches; Cast Iron Split and Solid Pulleys; Ball Bearing Loose Pulleys; Cut and Cast Gears of all types and materials; Safety Set Collars; Shaft Hangers; Pillow Blocks; Rigid and Flexible Couplings.

Also Clutch Pulleys, Sprocket Wheels, Rope Drives, Belt Tighteners and Mule Stands.

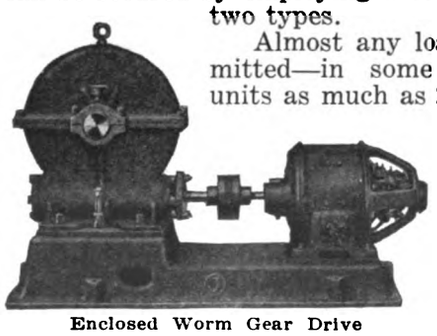
Spur Gear Speed Reducers

Jones Spur Gear and Worm Gear Speed Reducers are furnished in various ratios from 1¾ to



Spur Gear Speed Reducer Mounted on Cast Iron Base Coupled to Driven Shaft

1 up to 200 to 1. Exceptionally large reductions can be secured by employing a combination of the two types.



Enclosed Worm Gear Drive

Almost any load can be transmitted—in some of the larger units as much as 200 horse power. Jones Reducers are commonly used for driving conveyors, elevators, mixers, etc. Our engineers will gladly give your speed reduction problem a thorough analysis and recommend the proper machine.

Spur Gear

Gears

Jones Gears are made with cut or cast teeth as Spur Gears, Bevel Gears, Worm Gears, etc. The materials commonly used are Cast Iron, Steel, Rawhide, Bakelite, Bronze, etc.

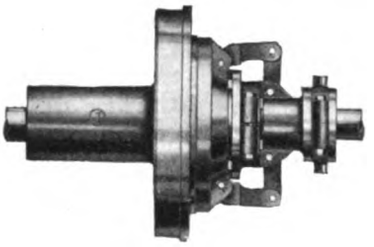
Ask for our new Gear Book.

Cast Iron Pulleys

Solid Cast Iron Pulley

Jones Cast Iron Pulleys are made either solid or split. They are furnished in any diameter up to 12 feet, for any width of belt and for any size shaft. The smaller castings are made on special pulley molding machines — insuring uniformity and smoothness. We make specially constructed pulleys to order.

Lemley Friction Clutches

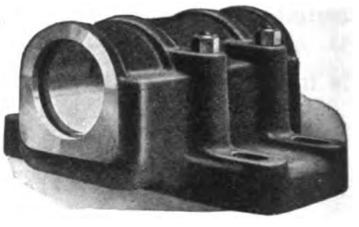


Lemley Standard Sleeve Cluth

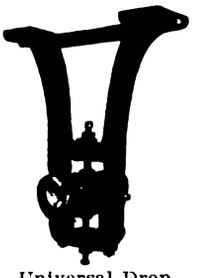
Furnished with extended sleeves for mounting pulleys, gears, sheaves, sprocket wheels, etc., also furnished as cut-off shaft couplings. Send for Friction Clutch Catalog and latest discounts.

Line Shaft Equipment

Standard Flange Coupling



Duplex Ring Oiling Rigid Pillow Block



Universal Drop Hanger

Plain Rigid Pillow Block

Repair Work

Exceptionally prompt attention is given to all orders for repairs, so that lost time due to breakdowns is reduced to a minimum.

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SECTION V

Electrical Machinery and Supplies

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

American Steel & Wire Co.
Bussmann Mfg. Co.
Chicago Fuse Mfg. Co.
Cutler-Hammer Mfg. Co., The
Economy Fuse & Mfg. Company
Federal Electric Co.
General Electric Co.
Gregory Electric Co.
Hazard Mfg. Company
Kuhlman Electric Co.
Moloney Electric Co.
Packard Electric Co., The
Pittsburgh Transformer Company
Rubber Insulated Metals Corp.
Salt Lake Hardware Co., The
Standard Underground Cable Co.
Stromberg-Carlson Telephone Mfg. Co.
Westinghouse Electric & Mfg. Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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Electrical Data

ELECTRICAL TERMS AND DEFINITIONS

Volt (E)—The unit of electrical motive force. Force required to send one ampere of current through one ohm of resistance.

Ohm (R)—Unit of resistance. The resistance offered to the passage of one ampere, when impelled by one volt.

Ampere (C) or (I)—Unit of current. The current which one volt can send through a resistance of one ohm.

Joule (J)—Unit of work. The work done by one watt in one second.

Watt (W)—The unit of electrical energy, and is the product of the ampere and volt. That is, one ampere of current flowing under a pressure of one volt gives one watt of energy.

Horse Power (H.P.)—Mechanical unit for measurement of power or rate of work.

Watt-hour—Electrical unit of work or energy. Watt-hours equals watts times hours.

Kilowatt-hour (K.W.-Hr.)—1,000 watt-hours. Large unit of work or energy.

Cycle—The period of a complete alternation of an alternating current circuit, comprising a positive and negative alternation.

Frequency—(of alternating current)—Number of cycles per second.

Single phase—The term applied to an alternating current circuit energized by a single alternating e.m.f. Such a circuit is usually supplied through two wires.

Polyphase—A general term applied to an alternating system with more than one phase. (See two-phase, three-phase, etc.)

Two-phase—The term applied to an alternating system comprising two electric circuits energized by alternating e.m.fs. which differ in phase by a quarter of a cycle—frequently referred to as quarter-phase.

Three-phase—The term applied to an alternating system comprising three electric circuits energized by alternating e.m.fs. which differ in phase by one-third of a cycle.

Power-factor (P.F.)—The power-factor is the ratio of the true power to the apparent power of an alternating current system. The apparent watts are equal to the product of the volts and amperes, but owing to possible "phase displacement" the power delivered, as measured by a watt-meter, may be actually less than the apparent power. The power factor may be expressed as a percentage but is usually written as a decimal fraction.

Circuit—A circuit is a path, made up of a conductor or several conductors joined together, through which an electric current may flow from a given point around the conducting path and back to the starting point.

Conductor—Material, such as copper wire, which serves to conduct electric current.

Volt-Amperes—Product of volts and amperes.

Kilovolt-Amperes (KVA)—1,000 volt amperes.

MOTOR CHARACTERISTICS

Direct current motors are divided into three classes, designated according to the method of connecting the armature and field windings as shunt, series and compound wound.

Alternating current motors are divided into two general classes—Induction and Synchronous, while Induction motors are of two types designated according to the type of rotor winding as the Squirrel Cage Type and as the Wound Rotor or Slip Ring Type.

Each of these types has special characteristics as mentioned below.

Shunt Wound D. C. Motors—This type of motor runs at practically constant speed regardless of the load. It is the type most generally used in commercial practice and is usually recommended where starting conditions are not unusually severe.

The speed of shunt motors may be regulated in two ways—first by inserting resistance in series with the armature, thus decreasing the speed, and second, by inserting resistance in the field circuit, thereby increasing the speed. In the former case the speed will vary with each change in load, in the latter the speed is practically constant for any setting of the controller. The latter is most generally used for adjustable speed service, as in the case of machine tools, etc.

Series Wound D. C. Motors—In this type of motor the speed varies automatically with the load, increasing as the load decreases. The use of series motors is generally limited to cases where a heavy power demand is necessary to bring the machines up to speed, as in the case of certain elevator and hoist installations, for street cars, etc. Series motors should never be used where the motor can be started without load, as they will race to a dangerous degree.

Compound Wound D. C. Motors—This is a combination of the shunt and series types, and combines the characteristics of both. These characteristics may be varied by varying the combination of the two windings. It is most generally used where severe starting conditions and constant speed are required at the same time.

Squirrel Cage Induction Motors—This is the most rugged and reliable of all electric motors. Having no sliding contacts, all danger of sparking is eliminated, and such motors may be used even where the fire hazard is great. They are essentially constant speed machines and should be used where starting conditions are not too severe.

Wound Rotor or Slip Ring Induction Motors—These motors are used for constant speed service requiring a heavier starting torque than is obtainable with the squirrel cage type. They are preferable for lighting circuits and in outlying districts where the line disturbance in starting a squirrel cage motor might be objectionable. On account of the lower starting current, this type is recommended in preference to the squirrel cage type in larger sizes.

Wound rotor motors are also used for varying speed service. The speed varies with this load, so that they should not be used where constant speed at each adjustment is required, as for machine tools.

Single phase induction motors are used, mostly in small sizes, where polyphase current is not available. Their starting characteristics are not as good as the polyphase motor and for sizes larger than 10 horse power the line disturbance is likely to be objectionable.

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Electrical Data---Continued

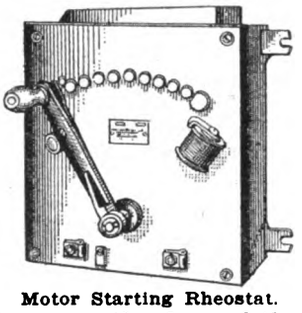
MOTOR CHARACTERISTICS—Continued

Synchronous motors run at a constant speed fixed by the frequency of the system. They require direct current for excitation and have low starting torque. For large motor-generator sets, frequency changers, air compressors and similar apparatus which permits starting under light load they are being generally used. They are used with considerable advantage, particularly on large power systems, on account of their inherent ability to improve the power factor of the system.

STARTING AND STOPPING MOTORS—DIRECT CURRENT

One rule to be remembered at all times in starting and stopping motors is switch first, rheostat last, which means in starting, close the switch first, and then gradually cut out all resistance as the motor speeds up. To stop the motor open the switch first, and then cut in all the resistance of the rheostat which is in series with the motor armature.

When starting a new motor for the first time, see that the belt is removed from the pulley and the motor started with no load. Never keep the rheostat handle on any of its coils longer than a moment, as they are not designed to regulate the speed of the motor, but to prevent too large a flow of current into the armature before the latter has attained its full speed.



Motor Starting Rheostat.

The illustration shows a rheostat in common use, designed to automatically protect the armature of a motor. The contact arm is fitted with a spring which constantly tends to throw the arm on the "off" point, and open the circuit, but is prevented from so doing, while the motor is in operation, by the small electro-magnet, shown on the face of the rheostat, which consists of low-resistance coil connected in series with the field winding of the motor. This magnet holds the contact arm of the rheostat at its extreme position, allowing the maximum working current to flow through the armature while it is in operation.

If for any reason the current supplied to the motor be momentarily cut off, the speed of the armature generates a counter current which also tends to hold the arm in position as long as there is any motion to the motor armature, but as soon as the armature ceases to revolve all current ceases to flow through the electro-magnet, thereby releasing the rheostat handle, which flies back to the "off" point, as shown in the illustration, and the motor armature is out of danger.

Such a device is of great value where inexperienced men have to handle motors, and are unaware that the first thing to be done when a motor stops is to open the circuit, and then cut in all the resistance in the rheostat to guard against an in-rush of current when the motor is started up again.

INQUIRY FORM FOR CARBON BRUSHES

The manufacturer tries in every respect to give the operating man the best and most suitable brush for his equipment, but requisitions for brushes frequently give the size, style of shunt and nothing else. While this information is very valuable to the manufacturer, he is at a loss to know for what service the brushes are to be used. The brush manufacturer cannot, in every case, correspond with the mine official, without holding up the order and delaying shipment, so naturally the best course is followed and the brush that is supplied is more or less a guess-work proposition.

When ordering brushes, therefore, give the following information:

Size of brush.....

Style of shunt.....

Number of brushes required.....

Bevel, if any.....

Ampere carrying capacity of machine.....

Speed under which machine is operated.....

Commutator, undercut or flush mica.....

What work does machine do?.....

A FEW GOOD GENERAL RULES

Keep your machine clean.

Do not habitually overload your machines.

After an armature has been repaired, or if it has stood idle for any length of time, use care in starting it up, let it run without a load for sufficient time to warm it up, thus drying up any moisture that might have accumulated in it. If you notice that it starts to smoke, shut it down, and let it cool off, then start it up again, and repeat this operation until you are thoroughly satisfied that it is dry.

Do not ship armatures away for repairs without boxing them very securely.

Do not let a few dollars in price influence you in sending your work to a firm that you know nothing about, for there are ways of cheapening repairs. Such repairs, however, are not cheap.

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POWER AND POWER FACTOR*

Power that is flowing between two points in an electric circuit at any instant, can be found by multiplying the current at that instant by the voltage at that instant between these points.

When the voltage and current are in phase, the average power is equal to the product of the effective volts times the effective amperes.

If there is a phase difference between the current and the voltage of 90°, no power is being delivered. All the energy leaving the generator is returned to it during each cycle.

If the current phase differs from the voltage phase by an angle less than 90°, the power delivered equals the effective volts times the effective amperes times cosine of the angle of phase difference (or angle of lag). This angle of lag is generally designated as Θ. Power factor is the cosine of Θ.

Apparent power is the name given to the product of volts times amperes. The units are known as volt-amperes to distinguish them from watts which are the units for measuring effective power.

$$\text{Power Factor} = \frac{\text{Effective Power}}{\text{Apparent Power}} = \frac{\text{Watts}}{\text{Volt-Amperes}}$$

An alternating current may be considered as made up of two component parts, differing in phase by 90°. The power component is in phase with the voltage and is equal to the product of the current times the cosine of the angle of phase difference, between the current and the voltage. The product of this component and the voltage measures the effective power or watts.

(Power Component) = (Amperes) × (Cos Θ)

(Watts) = (Power Component of Current) × (Voltage)

The reactive or wattless component lags or leads 90° from the voltage. This is equal to the product of the current times the sine of the angle of phase difference between the current and voltage. No power is delivered by this component.

(Reactive Component) = (Amperes) × (Sine Θ)

$$\begin{pmatrix}\text{Reactive}\\ \text{Volt}\\ \text{Amperes}\end{pmatrix} = \begin{pmatrix}\text{Reactive}\\ \text{Component of}\\ \text{Current}\end{pmatrix} \times (\text{Voltage})$$

How to Tell Power Factor of Your System

An operator can easily tell the power factor of his line at any time. In case there is no power factor meter, take readings (as nearly instantaneous as possible) from the wattmeter, †voltmeter and ammeter. Care must be taken to get average ampere reading of all the phases. Divide the total kilowatts (as shown by wattmeter) by the total kilovolt-amperes—the quotient is the power factor of the line at the time.

†Note—If it is desired to find the watts at any instant from a watthour meter, proceed as follows: Count the revolutions of the dial of the watthour meter during a certain time (a minute or more), then apply the following equation:

$$\text{Watts} = \frac{3600 \times K\,(\text{Watthour constant}) \times \text{Revolut'ns}}{\text{Time in seconds.}}$$

K is Watthour constant given on the meter.

It is readily seen that the total KW (effective power component) is the product of total KVA multiplied by the power factor.

The right angle triangle in Fig. 1 shows the vector relation of these quantities.

Fig. 1.

The line AB is the hypotenuse of the triangle and represents the total KVA; the line AC is the base and represents total KW. The angle Θ is formed by the cutting of AB by AC and is known as the angle of lag. The side opposite the angle of lag (BC) is the reactive (wattless) component.

The power factor is the cosine of the angle of lag. From your meter readings you have found the value of the side AB (total KVA) and the side AC (total KW) and the cosine of Θ (power factor).

The value of the side BC is found by the following formula: Square the value of AB or the total KVA; square the value of AC or the total KW; subtract the square of the total KW from the square of the total KVA; extract the square root of the remainder. This will be the value of the total reactive KVA, equivalent to the line BC. This is based on the simple geometric formula, that the square of the hypotenuse is equal to the sum of the squares of the other two sides.

Example: Suppose the total KVA is 500, and the total KW is 400. The square of 500 is 250,000; the square of 400 is 160,000 Subtract 160,000 from 250,000. 90,000 is the remainder. The square root of 90,000 is 300. 300 KVA is the wattless component—or value of the line BC.

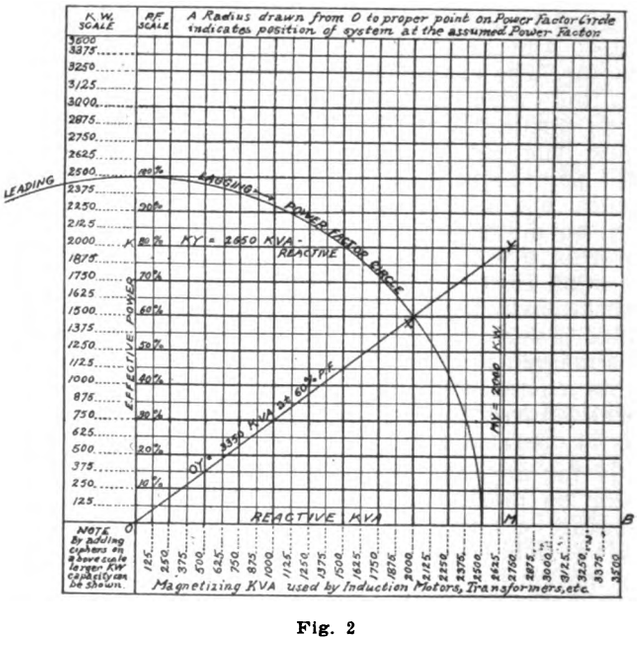

Fig. 2

Example: To find P.F. of any point on P.F. circle, follow horizontal line to left till it intersects P.F. scale.

OY represents a system of 3350 KVA at 60% P.F. The point X on the circle determines the position of the radius OX. The length of OY to scale determines the size of system. MY represents effective power. (2000KW) KY represents reactive KVA (wattless)—(2650 KVA). Angle KOY represents the angle of lag.

When the power factor changes a new radius must be drawn. The angle included between the radius OX and the vertical line OK is the angle of lag. The cosine of this angle of lag is the power factor. Go ahead and lay out your own problem.

*Electric Machinery Company.

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Electrical Data---Continued

METRIC SYSTEM OF WEIGHTS AND MEASURES

Measures of Lengths

1 Millimeter	=	0 001	Meter	= 0 0394	Inch
1 Centimeter	=	0.01	Meter	= 0.3937	Inch.
1 Decimeter	=	0 1	Meter	= 3.937	Inches
1 Meter	=	1	Meter	= 39 37	Inches
1 Dekameter	=	10	Meters	= 393.7	Inches
1 Hectometer	=	100	Meters	= 328 Feet, 1	Inch.
1 Kilometer	=	1000	Meters	=3280 Feet, 10	Inches.
1 Myriameter	=	10000	Meters	= 6.2137	Miles

It will be noticed that 10 Millimeters equal 1 Centimeter. 10 Centimeters equal 1 Decimeter, and so on

Measures of Volumes

1 Milliliter	=	0.001	Liter	= 0.061 Cubic Inch.
1 Centiliter	=	0.01	Liter	= 0.6102 Cubic Inch.
1 Deciliter	=	0.1	Liter	= 6.1022 Cubic Inches.
1 Liter	=	1	Liter	= 0.9081 Quart.
1 Dekaliter	=	10	Liters	= 9.081 Quarts.
1.Hectoliter	=	100.	Liters	= 2 Bushels, 3 35 Pecks
1 Kiloliter	=	1000	Liters	= 1.308 Cubic Yards.

Weights

1 Milligramme	=	0 001	Gramme	= 0.0154 Grain.
1 Centigramme	=	0 01	Gramme	= 0.1543 Grain.
1 Decigramme	=	0 1	Gramme	= 1.5432 Grains.
1 Gramme	=	1	Gramme	= 15.432 Grains
1 Dekagramme	=	10	Grammes	= 0.3527 Ounce.
1 Hectogramme	=	100	Grammes	= 3.5274 Ounces.
1 Kilogramme	=	1000.	Grammes	= 2.2046 Pounds.
1 Myriagramme	=	10000	Grammes	= 22.046 Pounds.

Metric and English Equivalents

Inches	=Millimeters ÷ 25 4	Lbs. Avoirdupois	=Kilogrammes x 2.20463
Feet	=Meters x 3.28083	Tons (2000 lbs.)	=Kilogrammes ÷ 907.18
Yards	=Meters x 1.09364	Lbs. per Foot	=Kilo. per Meter x .67196
Miles	=Kilometers ÷ 1.60935	Lbs. per Cu. Ft.	=Kilo. per Cu. Meter x .06243
Sq. In.	=Square Millimeters x 00155	Sq. Millimeters	=Square Inches x 645.137
Sq. Ft.	=Square Meters x 10.7641	Sq. Meter	=Square Feet x .0929
Acres	=Square Kilometers x 247 114	Grammes	=Ounces x 28.3495
Cu. In.	=Cubic Centimeters ÷ 16.3870	Grammes	=Pounds x 453.5926
Cu. Ft.	=Cubic Meters x 35.3140	Kilogrammes	=Pounds x .45359

KILOWATTS AND HORSEPOWER

0.746 Kilowatts Equals One Horsepower

Kilowatts to Horsepower				Horsepower to Kilowatts			
Kw.	Horsepower	Kw.	Horsepower	Hp.	Kilowatts	Hp.	Kilowatts
1	1.341	55	73.733	1	.746	55	41.03
2	2.681	60	80.436	2	1.492	60	44.76
3	4.022	65	87.139	3	2.238	65	48.49
4	5.363	70	93.842	4	2.984	70	52.22
5	6.703	75	100.545	5	3.730	75	55.95
6	8.044	80	107.248	6	4.476	80	59.68
7	9.384	85	113.951	7	5.222	85	63.41
8	10.725	90	120.654	8	5.968	90	67.14
9	12.065	95	127.357	9	6.714	95	70.87
10	13.406	100	134.048	10	7.460	100	74.60
11	14.747	110	147.47	11	8.206	110	82.06
12	16.087	120	160.87	12	8.952	120	89.52
13	17.428	130	174.28	13	9.698	130	96.98
14	18.768	140	187.68	14	10.444	140	104.44
15	20.109	150	201.09	15	11.190	150	111.90
16	21.450	160	214.50	16	11.936	160	119.36
17	22.790	170	227.90	17	12.682	170	126.82
18	24.131	180	241 31	18	13.428	180	134.28
19	25.471	190	254.71	19	14.174	190	141.74
20	26.812	200	268.12	20	14.920	200	149.20
22	29.493	220	294.93	22	16.412	220	164.12
24	32.174	240	321.74	24	17.904	240	179.04
26	34.856	260	348.56	26	19.396	260	193.96
28	37.537	280	375.37	28	20.888	280	208.88
30	40.218	300	402.18	30	22.380	300	223.80
32	42.899	325	435 69	32	23.872	325	242.45
34	45 580	350	469.21	34	25.364	350	261.1
36	48.261	400	536.24	36	26.856	400	298.4
38	50.943	450	603.27	38	28.348	450	335.7
40	53.624	500	670.30	40	29.840	500	373.0
42	56.305	600	804.36	42	31.332	600	447.6
44	58.986	700	938.42	44	32.824	700	522.2
46	61.667	800	1072 48	46	34.316	800	596.8
48	64.349	900	1206.54	48	35.808	900	671.4
50	67.030	1000	1340.60	50	37.300	1000	746.0

Courtesy Goodman Mfg. Co.

SPEED AND FREQUENCY TABLE

For A. C. Apparatus

Frequency	125 Cycles	60 Cycles	50 Cycles	40 Cycles	30 Cycles	25 Cycles
Alt. per Min.	15000	7200	6000	4800	3600	3000
POLES	SPEED					
2	7500	3600	3000	2400	1800	1500
4	3750	1800	1500	1200	900	750
6	2500	1200	1000	800	600	500
8	1875	900	750	600	450	375
10	1500	720	600	480	360	300
12	1250	600	500	400	300	250
14	1071	514	428	343	257	214
16	937½	450	375	300	225	187½
18	833⅓	400	333	266	200	167
20	750	360	300	240	180	150
22	682	327	273	218	164	136
24	625	300	250	200	150	125
26	577	277	231	185	138	115
28	536	257	214	173	129	107
30	500	240	200	160	120	100
32	469	225	187	150	113	94
34	441	212	177	141	106	88½
36	417	200	167	133	100	83⅓
38	395	189½	158	126	95	79
40	375	180	150	120	90	75
42	357	171	143	114	86	
44	341	163½	136	109	82	
46	326	156½	130	104	78	
48	312½	150	125	100		
50	300	144	120	96		
52	288	138½	115	92½		
54	277½	133⅓	111	89		
56	268	128½	107	86		
58	258½	124	103	83		
60	250	120	100	80		
62	242	116	97			
64	234⅓	112½	94			
66	227	109	91			
68	220½	106	88½			
70	214	103	86			
72	208⅓	100	83			
74	202½	97½	81			
76	197½	95				
78	192	92½				
80	187½	90				
82	183	88				
84	178½	86				
86	174½	84				
88	170½	82				
90	166⅔	80				
92	163	78				
94	159½	76½				
96	156	75				
98	153					
100	150					

CONSTANTS FOR TRANSMISSION LINE CALCULATIONS

Phases	Wires	Values of A	Values of K				Values of T			
			Per Cent Power Factor				Per Cent Power Factor			
			100	95	85	80	100	95	85	80
1		6.04	2160	2400	3000	3380	1.00	1.05	1.17	1.25
2	4	12.08	1080	1200	1500	1690	.50	.53	59	.62
3	3	9.06	1080	1200	1500	1690	58	61	.68	72

Wire No., B. & S. Gauge	Values of M							
	25 Cycles				60 Cycles			
	Per Cent Power Factor				Per Cent Power Factor			
	95	90	85	80	95	90	85	80
0000	1.23	1.29	1.33	1.34	1.62	1.84	1.99	2.09
000	1.18	1.22	1.24	1.24	1.49	1 66	1.77	1.95
00	1.14	1.16	1 16	1.16	1.34	1.52	1.60	1.66
0	1.10	1 11	1.10	1.09	1.31	1 40	1.46	1.49
1	1.07	1.07	1.05	1.03	1.24	1.30	1.34	1.36
2	1.05	1.04	1 02	1 00	1 18	1 23	1.25	1.26
3	1.03	1 02	1 00	1.00	1.14	1.17	1.18	1.17
4	1.02	1.00	1 00	1 00	1 11	1.12	1.11	1.10
5	1.00	1 00	1.00	1.00	1.08	1.08	1.06	1.04
6	1.00	1 00	1.00	1.00	1.05	1.04	1.02	1.00
7	1.00	1 00	1.00	1 00	1.03	1.02	1.00	1.00
8	1.00	1 00	1 00	1 00	1.02	1.00	1.00	1.00
9	1.00	1 00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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Electrical Data---Continued

FORMULAS USED IN ELECTRICAL CALCULATIONS

(For Abbreviations See Electrical Terms and Definitions)

K.W. = 1000 watts = 1.34 H.P.

H.P. = 746 watts = .746 K.W.

$$\text{K.V.A.} = \frac{\text{K.W.}}{\text{P.F.}}$$

$$\text{P.F.} = \frac{\text{true power}}{\text{apparent power}} = \frac{\text{Watts}}{\text{volts} \times \text{amperes}} = \frac{\text{K.W.}}{\text{K.V.A.}}$$

$$\text{K.W.} = \frac{E \times I}{1000} \quad \text{(Direct Current)}$$

$$\text{K.W.} = \frac{1.73 \times E \times I \times \text{P.F.}}{1000} \quad \text{(3 Phase Alternating Current)}$$

$$\text{K. W.} = \frac{2 \times E \times I \times \text{P.F.}}{1000} \quad \text{(2 Phase Alternating Current)}$$

$$\text{K.W.} = \frac{E \times I \times \text{P.F.}}{1000} \quad \text{(1 Phase Alternating Current)}$$

WIRING FORMULAS

$\text{CM} = \frac{22 \times LC}{V}$ Where load is at end of line.

$\text{CM} = \frac{11 \times LXC}{V}$ Where load is distributed along line.

CM = Circular mils.
L = Length in feet on one side of circuit.
C = Current in Amperes.
V = Loss in volts.

CURRENT FOR MOTORS.
Amperes for Each Lead at Full Load

HORSE POWER.	DIRECT CURRENT.		ALTERNATING CURRENT.		
			PHASE		
			Single	Two	Three
	VOLTS		VOLTS		
	110	220	208	200	200
½	4.9	2.5	4.9	...	...
1	9	4.5	7.8	...	...
1½	13.6	6.8	...	...	...
2	18	9	15.9	...	...
3	25	13	21.5	...	...
5	42	21	32.5	12.9	14.9
7½	57	28	48	19	22
10	75	38	68	25	29
15	113	57	90	37	43
20	150	75	115	49	58
30	226	113	161	72	84
40	301	150	...	96	111
50	376	188	...	118	136
60	452	226	...	140	163
70	527	263	...	163	187
80	602	301	...	185	213
90	678	339	...	207	239
100	753	376	...	230	265

Ohms Law (Direct current or non-inductive alternating current circuits):

$$I = \frac{E}{R}, \quad E = IR, \quad R = \frac{E}{I}$$

Amperes per motor (Current input per line):

Direct Current $I = \frac{\text{H.P.} \times 746}{E \times \text{Eff.}}$

3 Phase A.C. $I = \frac{\text{H.P.} \times 746}{1.73 \times E \times \text{Eff.} \times \text{P.F.}}$

2 Phase A.C. $I = \frac{\text{H.P.} \times 746}{2 \times E \times \text{Eff.} \times \text{P.F.}}$

1 Phase A.C. $I = \frac{\text{H.P.} \times 746}{E \times \text{Eff.} \times \text{P.F.}}$

FORMULAS—OHM'S LAW

$C = \frac{E}{R} \quad R = \frac{E}{C} \quad E = CR$

$W = EC = C^2R = \frac{R}{E^2}$

$\text{H. P.} = \frac{EC}{746} = \frac{C^2R}{746} = \frac{E^2}{R \times 746} = \frac{W}{746}$

E = Electromotiv force in volts.
R = Resistance in Ohms.
C = Current in Amperes.
W = Power in Watts.
H.P. = Horse-power.

EQUIVALENTS OF ELECTRICAL UNITS

1 Kilowatt = 1000 Watts.
1 Kilowatt = 1.34 Horse power.
1 Kilowatt = 42257 Ft.-lbs. per min.
1 Kilowatt = 56.87 B. T. U. per min.
1 Horse power = 746 Watts.
1 Horse power = 33000 Ft.-lbs. per min.
1 Horse power = 42.41 B. T. U. per min.
1 B. T. U. = 778 Foot-pounds.
1 B. T. U. = 0.2930 Watt hours.

RULES—VOLTS, AMPERES, WATTS, ETC.

To find the watts consumed in a given electrical circuit, such as a lamp, multiply the volts by the amperes.

To find the volts, divide the watts by the amperes.

To find the amperes, divide the watts by the volts.

To find the electrical horse-power required by a lamp, divide the watts of the lamp by 746.

To find the number of lamps that can be supplied by one electrical horse-power of energy, divide 746 by the watts of the lamp.

To find the electrical horse-power necessary multiply the watts per lamp by the number of lamps and divide by 746.

To find the mechanical horse-power necessary to generate the required electrical horse-power, divide the latter by the efficiency of the generator.

To find the amperes of a given circuit of which the volts and ohms resistance are known, divide the volts by the ohms

To find the volts, when the amperes and watts are known, multiply the amperes by the ohms.

To find the resistance in ohms, when the volts and amperes are known, divide the volts by the amperes.

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Electrical Data---Continued

VOLTS DROP IN BONDED TRACK
Losses Per Ampere per 1,000 Feet of Single Track
Rail Bonds of No. 1 Copper Wire

Weight of Rail, Pounds per Yard	Length of Bond, Feet	Volts Drop per Ampere per 1000 feet of Single Track			
		30-Ft. Rail Lengths		20-Ft. Rail Lengths	
		Single Bonded	Double Bonded	Single Bonded	Double Bonded
8	2½	0 0344	0.0318	0 0354	0.0317
12	2½	.0247	0221	0261	0224
16	2½	0198	0172	0214	0176
20	2½	0168	0142	.0188	0149
25	2½	.0145	0119	0166	0126
30	2½	0139	0108	0165	.0120
35	3	.0128	0097	0155	.0109
40	3	0120	0089	0148	0101
45	3	.0114	0083	.0142	.0096
50	3	0109	0078	0137	.0090
55	3	.0104	0073	0133	.0086
60	3	.0101	.0070	0129	0083
65	3	0098	.0067	.0126	.0080
70	3	.0095	.0064	.0124	.0077

ELECTRICAL PROPERTIES OF MINE TRACKS

Weights of Rail per Yard	Equivalent Area in Cir. Mils of Copper	Resistance at 24° C.		Loss in Volts per Amp. in 100 ft. Track	Safe Amp. 10° C. Rise
		Ohms per Mile	Ohms per 1000 ft.		
16	320000	.1737	.0329	.0033	500
20	400000	.1684	.0263	.0026	600
25	500000	.1109	.0210	.0021	675
30	600000	.0924	.0175	.0017	750
35	700000	.0792	.0150	.0015	850
40	800000	.0692	.0131	.0013	950
45	900000	.0616	.0117	.0012	1050
50	1000000	.0554	.0105	.0011	1150
55	1100000	.0504	.0095	.0010	1250
60	1200000	.0464	.0088	.0009	1300
65	1300000	.0417	.0079	.0008	1400
70	1400000	.0396	.0075	.00075	1500
80	1600000	.0345	.0065	.00065	1700
90	1800000	.0307	.0058	.00058	1900
100	2000000	.0270	.0051	.00051	2150

Calculated by Alex. Palmros, Dec., '07

SIZE OF FUSES, IN AMPERES, FOR MOTORS EQUIPPED WITH OVERLOAD STARTING RHEOSTATS

Horse Power	115 Volts	230 Volts	500 Volts
0.5	8	4	2
1	15	8	4
3	40	20	10
4	50	25	12
5	60	30	15
7.5	90	45	20
10	115	60	25
15	175	90	40
20	225	115	50
25	300	150	60
30	350	175	75
35	400	200	90
40	450	225	100
50	600	300	125

VOLTS LOST WITH VARIOUS COPPER WIRE COMBINATIONS

Sizes of Wires	Area, Circular Mils.	Weight of Combination, Pounds per 1000 feet.	Volts Lost per Ampere per 1000 feet.
One No. 0000 and One No. 000	379405	1149	0 027
" " " " " 00	344679	1044	030
" " " " " 0	317192	960	.033
" " " " " 1	295295	894	035
One No. 0000 and Two No. 000	547210	1657	019
" " " " " 00	477758	1447	022
" " " " " 0	422784	1280	.025
" " " " " 1	378990	1148	027
One No. 000 and One No. 00	300884	911	035
" " " " " 0	.273397	828	038
" " " " " 1	251500	762	041
One No. 000 and Two No. 00	433963	1314	.024
" " " " " 0	378989	1147	.027
" " " " " 1	335195	1015	.031
One No. 00 and One No. 0	238671	723	.043
" " " " " 1	216774	656	.048
One No. 00 and Two No. 0	344263	1042	.030
" " " " " " 1	300469	910	.035
One No. 0 and One No. 1	189287	573	.055
One No. 0 and Two No. 1	272982	827	.038

WEIGHT OF BARE COPPER WIRE

Wire No. B. & S. Gauge	Diameter, Inches	Area, Circular Mils	Weight of Bare Wire, Pounds	
			Per 1000 Feet	Per Mile
0000	0.460	211600	640.7	3383
000	.410	167805	508.1	2683
00	365	133079	403.0	2128
0	325	105592	319 7	1688
1	.289	83695	253.4	1338
2	.258	56373	201.0	1061
3	.229	52634	159.4	841.5
4	204	41743	126.4	667.4
5	.182	33102	100.2	529.2
6	.162	26251	79.5	419.7
7	144	20817	63.0	332.8
8	.129	16510	50.0	264.0
9	.114	13094	39.7	209.4
10	.102	10382	31.4	166.0
11	.091	8234	24.9	131.7
12	.081	6230	19.8	104.4
13	.072	5178	15.7	82.8
14	.064	4107	12.4	65.7
15	.057	3257	9.86	52.07
16	.051	2583	7.82	41.29
17	.045	2048	6.20	32.75
18	.040	1624	4.92	25.97
19	.036	1288	3.90	20.59
20	032	1021	3.09	16.33
21	.029	810.1	2.45	12.95
22	.025	642.5	1.95	10.27
23	.023	509.5	1.54	8.15
24	.020	404.0	1.22	6.46
25	.018	320.4	.97	5.12
26	.016	254.1	.77	4.06

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Electrical Data---Continued

RESISTANCE OF COPPER AND ALUMINUM WIRE AT 75° FAHRENHEIT

Conductivity: Copper 98%; Aluminum 62%

Wire No., B.&S. Gauge	Area, Circular Mils	Copper			Aluminum		
		Volts Lost per Ampere		Feet per Ohm	Volts Lost per Ampere		Feet per Ohm
		Per 1000 Feet	Per Mile		Per 1000 Feet	Per Mile	
0000	211600	0.049	0.259	20393	0.078	0.410	12888.9
000	167805	.062	.327	16172	.098	.517	10236.9
00	133079	.078	.412	12825	.123	.652	8118.5
0	105592	.098	.519	10176	.155	.822	6441.7
1	83695	.124	.655	8066	.196	1.036	5105.8
2	66373	.156	.825	6396.7	.247	1.306	4049.1
3	52634	.197	1.04	5072.5	.311	1.646	2546.5
4	41743	.249	1.31	4022.9	.393	2.075	3210.9
5	33102	.314	1.66	3190.2	.496	2.620	2019.4
6	26251	.395	2.09	2529.9	625	3.305	1601.4
7	20817	.499	2.63	2006.2	789	4.173	1269.9
8	16510	.629	3.32	1591.1	.994	5.255	1007.2
9	13094	.792	4.18	1262.0	1.253	6.627	798.8
10	10382	1.00	5.28	1000.5	1.580	8.360	633.3
11	8234	1.26	6.65	793.6	1.990	10.53	502.32
12	6230	1.59	8.39	629.3	2.513	13.29	398.35
13	5178	2.00	10.58	499.1	3.167	16.75	315.90
14	4107	2.53	13.34	395.8	3.992	21.10	250.54
15	3257	3.19	16.82	313.9	5.035	26.66	198.68
16	2583	4.02	21.21	248.9	6.345	33.55	157.55
17	2048	5.07	26.75	197.4	8.013	42.30	124.95
18	1624	6.39	33.73	156.5	10.11	53.40	99.09
19	1288	8.06	42.53	124.1	12.73	67.25	78.58
20	1021	10.16	53.64	98.44	16.07	85.06	62.31
21	810.1	12.81	67.63	78.07	20.25	107.1	49.42
22	642.5	16.15	85.27	61.92	25.53	134.9	39.20
23	509.5	20.37	107.5	49.10	32.20	170.3	31.08
24	404.0	25.68	135.6	38.94	40.65	214.8	24.65
25	320.4	32.38	171.0	30.88	51.23	271.0	19.55
26	254.1	40.84	215.6	24.49	64.65	341.8	15 50

PROPERTIES OF STRANDED COPPER AND ALUMINUM CABLE AT 75° FAHRENHEIT

Conductivity: Copper 98%; Aluminum 62%

Wire No., B.&S. Gauge	Area, Circular Mils	Copper			Aluminum		
		Weight of Bare Cable, Pounds		Volts Lost per Ampere per 1000 Feet	Weight of Bare Cable, Pounds		Volts Lost per Ampere per 1000 Feet
		Per 1000 Feet	Per Mile		Per 1000 Feet	Per Mile	
	1000000	3050	16104	0.0105	920	4858	0.0166
	950000	2898	15299	.0111	874	4617	0175
	900000	2745	14494	0117	828	4374	0185
	850000	2593	13688	0124	782	4131	0196
	800000	2440	12883	.0131	736	3888	.0207
	750000	2288	12078	.0140	690	3645	.0221
	700000	2135	11273	.0150	644	3402	.0237
	650000	1983	10468	.0162	598	3159	0256
	600000	1830	9662	.0175	552	2916	.0276
	550000	1678	8857	.0191	506	2673	.0302
	500000	1525	8052	.0210	460	2430	.0332
	450000	1373	7247	0234	414	2187	0370
	400000	1220	6442	.0263	368	1944	.0416
	350000	1068	5636	0300	322	1701	.0474
	300000	915	4831	.0350	276	1458	.0553
	250000	762	4026	0420	230	1215	0664
0000	211600	645	3405	.0497	194.7	1028	.0785
000	167805	513	2709	0625	154.4	816	.0987
00	133079	406	2144	0789	122.4	647	1247
0	105592	322	1700	0995	97.1	513	1573
1	83695	255	1346	.1258	77.0	407	1988
2	66373	203	1072	.1579	61.0	323	.2495
3	52634	160	845	2004	48.5	256	3168
4	41743	127	671	2525	38.5	203	3990
5	33102	103	544	.3112	30.2	161	.4920
6	26251	81	428	.3960	24.1	128	.6260

BREAKING STRAIN OF COPPER AND ALUMINUM WIRE AND CABLE

Ultimate strength of Annealed Copper taken at 34,000 pounds per square inch.

Ultimate strength of Hard Drawn Copper taken at 60,000 pounds per square inch, except: 50,000 pounds for Nos. 0000, 000 and 00; 55,000 pounds for No. 0; 57,000 pounds for No. 1.

Ultimate strength of Aluminum taken at 26,000 pounds per square inch.

Table gives actual breaking strains, to which a suitable safety factor must be applied to secure proper working strengths.

Wire No., B. & S. Gauge	Area, Circular Mils	Breaking Strain, Pounds			
		Copper, Solid		Aluminum	
		Annealed	Hard Drawn	Solid	Stranded
	1000000			20420	32280
	900000			18380	29050
	800000			16340	25820
	700000			14300	22590
	600000			12250	19370
	500000			10210	16140
	400000			8170	12910
	300000			6130	9680
	250000			5110	8070
0000	211600	5650	8310	4320	6830
000	167805	4475	6580	3430	5420
00	133079	3550	5226	2720	4290
0	105592	2800	4558	2150	3410
1	83695	2225	3746	1710	2700
2	66373	1775	3127	1355	2143
3	52634	1400	2480	1075	1700
4	41743	1115	1967	852	1350
5	33102	885	1519	657	1070
6	26251	700	1237	536	850
7	20817	550	980	426	
8	16510	440	778	337	
9	13094	350	617	267	
10	10382	275	489	212	
11	8234	220	388	167	
12	6230	175	307	133	
13	5178	135	244	105	
14	4107	110	193	84	

Courtesy Goodman Mfg. Co

CARRYING CAPACITY OF INTERIOR CONDUCTORS

The Question of Drop is Not Taken Into Consideration in These Tables

The following table shows the allowable carrying capacity of wires and cables of 98% conductivity.

The lower limit is specified for rubber covered wires to prevent gradual deterioration of the insulation by the heat of the wires, but not from fear of igniting the insulation.—"N. B. of F. U."

Copper B. & S. Gauge	Concealed Rubber-Covered Wires	Exposed Weatherproof Wires	Circular Mils.	Concealed Rubber-Covered Wires	Exposed Weatherproof Wires
	Amps.	Amps.		Amps.	Amps.
18	3	5	200,000	200	300
16	6	8	300,000	270	400
14	12	16	400,000	330	500
12	17	23	500,000	390	590
10	24	32	600,000	450	680
			700,000	500	760
			800,000	550	840
8	33	46	900,000	600	920
6	46	65	1,000,000	650	1,000
5	54	77	1,100,000	690	1,080
4	65	92			
3	76	110	1,200,000	730	1,150
			1,300,000	770	1,220
			1,400,000	810	1,290
			1,500,000	850	1,360
2	90	131	1,600,000	890	1,430
1	107	156			
0	127	185	1,700,000	930	1,490
00	150	220	1,800,000	970	1,550
000	177	262	1,900,000	1,010	1,610
0000	210	313	2,000,000	1,050	1,670

Courtesy Hazard Mfg. Co.

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Electrical Data---Continued

DIAMETER AND WEIGHT OF STANDARD WEATHERPROOF INSULATED COPPER WIRE AND CABLE

Double Braid

Wire No., B. & S. Gauge	Area, Circular Mils	Solid		Stranded	
		Diameter, Inches	Weight, Pounds per 1000 Feet	Diameter, Inches	Weight, Pounds per 1000 Feet
	1000000	.....	.....	1.37	3456
	900000	.....	.....	1.31	3127
	800000	.....	.....	1.24	2799
	700000	.....	.....	1.18	2471
	600000	.....	.....	1.11	2093
	500000	.....	.....	1.03	1765
	400000	.....	.....	.94	1436
	300000	.....	.....	.85	1083
0000	211600	0.61	723	.71	745
000	167805	56	587	.65	604
00	133079	.52	467	.60	482
0	105592	.47	377	.56	388
1	83695	.41	294	.47	303
2	66373	.37	239	.42	246
3	52634	.35	185	.38	190
4	41743	.32	151	.35	155
5	33102	30	122	32	126
6	26251	.28	100	.31	103

DIAMETER AND WEIGHT OF STANDARD WEATHERPROOF INSULATED COPPER WIRE AND CABLE

Triple Braid

Wire No., B. & S. Gauge	Area, Circular Mils	Solid		Stranded	
		Diameter, Inches	Weight, Pounds per 1000 Feet	Diameter Inches	Weight, Pounds per 1000 Feet
	1000000	.....	.....	1.45	3674
	900000	.....	.....	1.39	3332
	800000	.....	.....	1 33	2992
	700000	.....	.....	1.27	2650
	600000	.....	.....	1.19	2235
	500000	.....	.....	1.11	1894
	400000	.....	.....	1.02	1553
	300000	.....	.....	.93	1174
0000	211600	0.66	767	.79	800
000	167805	.60	629	73	653
00	133079	.55	502	66	522
0	105592	.51	407	61	424
1	83695	.45	316	.52	328
2	66373	.40	260	.44	270
3	52634	.37	208	.41	219
4	41743	.35	164	.38	170
5	33102	.32	130	.35	146
6	26251	.30	112	.33	115

DIAMETER AND WEIGHT OF RUBBER INSULATED COPPER WIRE AND CABLE

National Electric Code Standard. 0 to 600 Volts

Double Braid

Wire No., B. & S. Gauge	Area, Circular Mils	Solid		Stranded	
		Diameter, Inches	Weight, Pounds per 1000 Feet	Diameter, Inches	Weight, Pounds per 1000 Feet
	1000000			1.46	3553
	900000			1.40	3223
	800000			1.33	2891
	700000			1.27	2557
	600000			1.19	2220
	500000			1.09	1842
	400000			1.00	1514
	300000			.90	1173
0000	211600	0.70	793	.77	833
000	167805	.65	646	.71	675
00	133079	.61	528	.66	556
0	105592	.57	439	.61	457
1	83695	.53	363	.57	377
2	66373	.45	276	.50	293
3	52634	.42	228	.45	238
4	41743	.39	190	.42	198
5	33102	.36	154	.40	166
6	26251	.34	130	.36	136
7	20817	.30	105	.32	108
8	16510	.27	82 1	.29	85 5
9	13094	.26	68.4	.27	70 0
10	10382	.25	58.1	.26	60 6
11	8234	.24	50.0	.25	52 3
12	6230	.23	43 1	24	44 9
13	5178	.22	38.5	.23	39 6
14	4107	.21	33.9	.22	34.3

DIAMETER AND WEIGHT OF RUBBER INSULATED COPPER WIRE AND CABLE

National Electric Code Standard. 0 to 600 Volts

Triple Braid

Wire No., B. & S. Gauge	Area, Circular Mils	Solid		Stranded	
		Diameter, Inches	Weight, Pounds per 1000 Feet	Diameter, Inches	Weight, Pounds per 1000 Feet
	1000000	.....	.....	1.54	3637
	900000	.....	.....	1.48	3304
	800000	.....	.....	1.42	2968
	700000	.....	.....	1.35	2631
	600000	.....	.....	1.28	2290
	500000	.....	.....	1.17	1906
	400000	.....	.....	1.09	1573
	300000	.....	.....	.99	1226
0000	211600	0.78	835	.85	879
000	167805	.73	685	.79	719
00	133079	.69	564	.74	595
0	105592	.65	474	.70	494
1	83695	.61	395	.66	412
2	66373	.51	297	.59	324
3	52634	.48	247	.52	260
4	41743	.46	208	.49	218
5	33102	.41	167	.46	184
6	26251	.39	142	.41	149

Courtesy Goodman Mfg. Co.

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Electrical Data---Continued

Table I—Properties of Bare and Insulated Solid Copper Wire

Size B. & S.	Area		Diameter				Weight—Pounds per 1000 Ft.			Resistance Ohms per 1,000 Ft. at 68 Degrees Fahr.
			Bare		Over Insulation			Insulated		
	Circular Mils	Square Inches	Inches	Millimeters	3 Braid	2 Braid	Bare	3 Braid	2 Braid	
0000	211,600	.16619	.4600	11.683	.640	.609	640.5	767	728	.04893
000	167,772	.13177	.4096	10.404	.593	.562	507.8	629	587	.06170
00	133,079	.10452	.3648	9.266	.515	.500	402.8	502	467	.07780
0	105,625	.08295	.3250	8.251	.500	.468	319.7	407	377	.09811
1	83,694	.06573	.2893	7.348	.453	.422	253.3	316	294	.12370
2	66,358	.05211	.2576	6.544	.437	.390	200.8	260	239	.15600
3	52,624	.04133	.2294	5.827	.406	.359	159.3	199	185	.19670
4	41,738	.03278	.2043	5.190	.359	.328	126.3	164	151	.24800
6	26,244	.02061	.1620	4.115	.328	.296	80.6	112	100	.39440
8	16,512	.01297	.1285	3.263	.296	.250	49.9	75	66	.62710
10	10,384	.00815	.1019	2.588	.234	.203	31.4	53	46	.99720
12	6,528	.00512	.0808	2.052	.203	.172	19.7	35	30	1.58600
14	4,108	.00322	.0641	1.628	.187	.156	12.4	25	20	2.52100
16	2,580	.00202	.0508	1.291	.172	.125	7.8	20	16	4.00900
18	1,624	.00127	.0403	1.024	.156	.109	4.9	16	12	6.37400
20	1,024	.00080	.0320	.8118			3.1	12	9	10.14000

Table II—Properties of Bare and Insulated Stranded Copper Cable

Size B. & S. Gauge	Area		No. of Wires in Strand	Diameter			Weight—Pounds per 1,000 Feet			Resistance Ohms per 1,000 Ft. at 68 Degrees Fahr.
				Bare	Over Insulation		Bare	Insulated		
	Circular Mils	Square Inches			3 Braid	2 Braid		3 Braid	2 Braid	
	2,000,000	1.56874	91	1.6302	2.000	1.875	6204.8	7008	6690	0.00530
	1,750,000	1.36494	91	1.5257	1.906	1.781	5429.3	6193	5894	.00607
	1,500,000	1.17831	91	1.4124	1.781	1.656	4653.6	5380	5098	.00707
	1,250,000	.98170	91	1.2892	1.656	1.531	3878.0	4508	4264	.00852
	1,000,000	.78494	61	1.1520	1.531	1.406	3100.3	3674	3456	.01060
	950,000	.74618	61	1.1232	1.468	1.343	2945.3	3503	3292	.01115
	900,000	.70724	61	1.0935	1.437	1.312	2790.3	3332	3127	.01179
	850,000	.66852	61	1.0629	1.406	1.281	2635.3	3162	2963	.01247
	800,000	.62810	61	1.0305	1.375	1.250	2480.2	2992	2799	.01325
	750,000	.58922	61	.9981	1.343	1.218	2325.2	2822	2635	.01413
	700,000	.54954	61	.9639	1.312	1.187	2170.2	2650	2471	.01514
	650,000	.51020	61	.9288	1.250	1.125	2015.2	2443	2282	.01630
	600,000	.47146	61	.8928	1.234	1.109	1860.2	2235	2093	.01767
	550,000	.43181	37	.8533	1.156	1.031	1703.0	2064	1925	.01925
	500,000	.39237	37	.8134	1.109	1.000	1548.2	1894	1765	.02116
	450,000	.35284	37	.7721	1.062	.937	1393.4	1724	1601	.02349
	400,000	.31431	37	.7280	1.031	.906	1238.5	1553	1436	.02648
	350,000	.27511	19	.6785	.968	.843	1083.34	1345	1248	.03026
	300,000	.23591	19	.6285	.921	.796	926.01	1174	1083	.03531
	250,000	.19635	19	.5738	.875	.750	771.67	985	907	.04233
0000	211,600	.16609	19	.5275	.812	.687	653.14	800	745	.04997
000	167,772	.13185	7	.4644	.734	.671	512.07	653	604	.06293
00	133,079	.10429	7	.4134	.687	.625	406.98	522	482	.07935
0	105,625	.08303	7	.3684	.640	.578	322.39	424	388	.10007
1	83,694	.06599	7	.3279	.593	.531	255.45	338	303	.12617
2	66,358	.05205	7	.2919	.531	.468	202.50	270	246	.15725
3	52,624	.04132	7	.2601	.468	.421	160.60	206	190	.19827
4	41,738	.03276	7	.2316	.437	.390	127.40	170	155	.25000
6	26,244	.02059	7	.1836	.406	.359	80.10	115	108	.39767

The table herewith gives the approximate drop in voltage of a 250 volt two-wire system with conditions of trolley and feeder as ordinarily encountered in the average coal mine.

Loss of Voltage in Mines (Two Wire System)

250 Volts at Mine Entrance. Track Resistance Equal to Overhead Resistance, 100 Amperes in Circuit.

Distance in Mine in Feet	Volts Loss			Volts Between Track and Trolley		
	One 4-0 Trolley Only	One 4-0 Trolley and one 4-0 Feeder	One 4-0 Trolley and two 4-0 Feeders	One 4-0 Trolley Only	One 4-0 Trolley and one 4-0 Feeder	One 4-0 Trolley and two 4-0 Feeders
1,000	10	5	3	240	245	247
2,000	19	10	6	231	240	244
3,000	29	14	10	221	236	240
4,000	39	19	13	211	231	237
5,000	49	24	16	201	226	234
6,000	59	29	20	191	221	230
7,000	68	34	23	182	216	227
8,000	78	39	26	172	211	224
9,000	88	44	29	162	206	221
10,000	98	48	33	152	201	214
12,000	117	59	39	133	191	211
15,000	146	73	49	104	177	201

To Find Voltage at Any Other Current:—Divide current in amperes by 100 and multiply the result by the volts loss in the table.

Example:—Required, voltage between trolley and track, in a mine using 4-0 trolley and one 4-0 feeder at a point 3000 feet from the mine entrance. Current 500 amperes.

Solution:—Volts loss with 4-0 trolley and 4-0 feeder at 3000 feet equals 14. 500 amperes divided by 100 equals 5. 5 multiplied by 14 equals 70 equals volts loss. 250 volts at mine entrance less 70 volts loss equals 180 volts between trolley and track.

To find loss in mine using 3-0 trolley or feeder, multiply loss in Table by 1.261.

To find loss in mine using 2-0 trolley or feeder multiply volts loss in table by 1.509.

Example:—Required, voltage in mine using 3-0 trolley and two 3-0 feeders at a point 5,000 feet from the mine entrance, current 100 amperes.

Solution:—Look in Table and find under one 4-0 trolley and two 4-0 feeders and opposite 5,000 feet the loss to be 16 volts. Multiply 16 by 1.261, which gives 20 volts. 250 volts minus 20 volts equals 230 volts equals answer.

To find current taken by a 250 volt motor, multiply the horsepower by three.

To find current taken by a 500 volt motor, multiply the horse power by one and one-half.

RELATIVE RESISTANCE OF METALS AND ALLOYS

Copper	1.00	Iron (annealed)	6.14
Silver (hard drawn)	1.00	Nickel (annealed)	7.85
Gold (hard drawn)	1.31	Tin (pressed)	8.29
Zinc (pressed)	3.55	Lead (pressed)	12.15
Brass (35% Zinc)	4.65	German Silver	13.16
Platinum (annealed)	5.70	Mercury	59.50

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TRANSFORMERS FOR SUPPLYING LIGHTING AND POWER SERVICE
Standard Types, Frequencies, Sizes and Voltage Ratings

Note.—Voltage ratings in bold type will be considered the normal voltage ratings of these lines and guarantees will be made only on these normal voltage ratings. It is understood, however, that where a transformer is suitable for operation at two voltage ratings or at three voltage ratings, this flexibility will be definitely indicated on the name plate, on the connection diagram or on a paster inside the transformer cover.

TABLE I—SINGLE PHASE DISTRIBUTION TRANSFORMERS SIZES 200 KV-A. AND BELOW

STANDARD TYPES
Oil Immersed—Self Cooled

STANDARD SIZES IN KV-A. CONTINUOUS RATINGS AT 55 DEG. C. RISE
1.5-2.5-3-5-7.5-10-15-25-37.5-50-75-100-150-200
Note.—See following Table for sizes that are standard for the various system voltages.

STANDARD FREQUENCIES
25 Cycles per Second
60 Cycles per Second

STANDARD SIZES, VOLTAGE RATINGS AND TAPS OF TRANSFORMERS FOR THE VARIOUS SYSTEM VOLTAGES

Standard System Voltages	Standard Sizes for Each Voltage Class	For Supplying Service Voltages 600 and Below: Transformer High Voltage Ratings for Operation from Various Standard System Voltages — On Full Winding	Approximately on Taps			For Supplying Service Voltages 600 and Below: Transformer Low Voltage Ratings for Supplying Service Voltages 600 and Below	For Supplying Distribution Voltages Above 600: Transformer High Voltage Ratings for Operation from Various Standard System Voltages — On Full Winding	Approximately: On 5% Tap	Approximately: On 10% Tap	For Supplying Distribution Voltages Above 600: Transformer Low Voltage Ratings for Supplying Nominal 2300- or 4000-volt Distribution
440	1.5-3 to 100 incl.	440 **460** 480				...to 110/220 ...to **115/230** ...to 120/240				
550	1.5-3 to 100 incl.	550 **575** 600				...to 110/220 ...to **115/230** ...to 120/240				
2300	1.5-3 to 200 incl.	2200 **2300** 2400				...to 110/220..or to 220/440..or to 550 ...to **115/230**..or to **230/460**..or to **575** ...to 120/240..or to 240/480..or to 600				
4600	1.5-3 to 200 incl.	2200/4400 **2300/4600** 2400/4800				...to 110/220 ...to **115/230** ...to 120/240				
6600	1.5-3 to 200 incl.	6600/11430Y **6900/11950Y** 7200/12470Y	6300 6585 6875	6000 6275 6545	5700 (See Note) 5960 6220	...to 110/220..or to 220/440..or to 550 ...to **115/230**..or to **230/460**..or to **575** ...to 120/240..or to 240/480..or to 600	6600/11430Y	6270	5940	.....to **2300** (See Note)
11000	2.5-5-10 to 200 incl.	11000 **11500**	10450 10925	9900 10350		...to 110/220..or to 220/440..or to 550 ...to **115/230**..or to **230/460**..or to **575**	**11000**	10450	9900	.....to **2300/4000Y**
13200	2.5-5-10 to 200 incl.	13200 **13800**	12540 13110	11880 12420		...to 110/220..or to 220/440..or to 550 ...to **115/230**..or to **230/460**..or to **575**	**13200**	12540	11880	.....to **2300/4000Y**
22000	5-10 to 200 incl.	22000 **23000**	20900 21850	19800 20700		...to 110/220..or to 220/440..or to 550 ...to **115/230**..or to **230/460**..or to **575**	**22000**	20900	19800	.....to **2300/4000Y**
33000	10 to 200 incl.	33000 **34500**	31350 32775	29700 31050		...to 110/220..or to 220/440..or to 550 ...to **115/230**..or to **230/460**..or to **575**	**33000**	31350	29700	.....to **2300/4000Y**

Note—Transformers having low voltage rating of 115/230 for sizes 100 kv-a. and below are arranged for series, multiple or three-wire service by connection of the low voltage leads outside of the transformer tank; whereas, sizes 150 and 200 kv-a. are suitable for series or three-wire service only. Transformers having low voltage rating of 230-460 for sizes 200 kv-a. and below, are suitable for series or multiple service only.
These odd taps for distribution transformers of the 6600-volt class are chosen because of present established practice.

Note—Standard Single-phase Distribution Transformers for supplying nominal 2300- or 4000-volt distribution and having voltage ratings listed above, will be designed for successful operation when excited on full winding at 5% above their rated voltage.
Transformers having voltage ratings of 6600/11430Y to 2300, are when operated in bank, suitable for transforming from 6600 to 2300; from 6600 to 4000Y or from 11430Y to 2300. They should not be used connected in "Y" on both high and low voltage sides simultaneously to transform from 11430Y to 4000Y as this connection may result in excessive stress in the windings due to harmonic voltages.

Standard transformers having voltage ratings listed above will be designed for full rated kv-a. output at any specified tap voltage (not exceeding 10 per cent. range) without exceeding guaranteed temperature rise.

TABLE II—THREE PHASE DISTRIBUTION TRANSFORMERS SIZES 200 KV-A. AND BELOW

STANDARD TYPES
Oil Immersed—Self Cooled

STANDARD SIZES IN KV-A. CONTINUOUS RATINGS AT 55 DEG. C. RISE
5-7.5-10-15-25-37.5-50-75-100-150-200
Note.—See following Table for sizes that are standard for the various system voltages.

STANDARD FREQUENCIES
25 Cycles per Second
60 Cycles per Second

STANDARD SIZES, VOLTAGE RATINGS AND TAPS OF TRANSFORMERS FOR THE VARIOUS SYSTEM VOLTAGES

Standard System Voltages	Standard Sizes for Each Voltage Class	For Supplying Service Voltages 600 and Below: Transformer High Voltage Ratings for Operation from Various Standard System Voltages — On Full Winding	Approximately on 10% Tap	For Supplying Service Voltages 600 and Below: Transformer Low Voltage Ratings for Supplying Service Voltages 600 and Below
2300	5 to 200 incl.	2200/3810Y **2300/4000Y** 2400/4150Y		.....to **220/440** .....to **230/460** .....to **240/480**
4600	5 to 200 incl.	4400Y **4600Y** 4800Y		.....to **220/440** .....to **230/460** .....to **240/480**
6600	10 to 200 incl.	6600Y **6900Y** 7200Y	5940 6210 6480	.....to **220/440** .....to **230/460** .....to **240/480**
11000	10 to 200 incl.	11000Y **11500Y**	9900 10350	.....to **220/440** .....to **230/460**
13200	10 to 200 incl.	13200Y **13800Y**	11880 12420	.....to **220/440** .....to **230/460**
22000	15 to 200 incl.	22000Y **23000Y**	19800 20700	.....to **220/440** .....to **230/460**
33000	37.5 to 200 incl.	33000Y **34500Y**	29700 31050	.....to **220/440** .....to **230/460**

Note.—All sizes of distribution transformers having low voltage ratings of 230/460 are suitable for series or multiple three-phase service only by proper connection inside of the tank.

Standard transformers having voltage ratings listed above will be designed for full rated kv-a. output at any specified tap voltage without exceeding temperature rise. In general standard three-phase distribution transformers are not suitable for multiple operation with a bank of standard single-phase distribution transformers as the angular displacement, turn ratio and impedance volts on which successful multiple operation depends are generally different on three-phase and single-phase transformers.

(Adopted Standard to take effect January 1, 1921.)

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TABLE III—SINGLE PHASE POWER TRANSFORMERS

Sizes Above 200 KV-A.

For Supplying Lighting and Power Service.. Standard Types, Frequencies, Sizes and Voltage Ratings.

STANDARD TYPES

Oil Immersed—Self Cooled
Oil Immersed—Water Cooled
Air Blast

Note—The application of Air Blast Transformers should be confined to systems where the voltage does not exceed 25,000

STANDARD SIZES IN KV-A. CONTINUOUS RATINGS AT 55 DEG. C. RISE

Oil Immersed—Self Cooled				Oil Immersed—Water Cooled or Air Blast			
250	667	1667	5000	500	1250	3333	10000
333	833	2000	6667	667	1667	5000	
400	1000	2500	8333	833	2000	6667	
500	1250	3333	10000	1000	2500	8333	

Note—See following table for sizes that are standard for the various system voltages.

STANDARD FREQUENCIES

25 Cycles per Second
60 Cycles per Second

STANDARD SIZES, VOLTAGE RATINGS AND TAPS OF SUBSTATION TRANSFORMERS FOR THE VARIOUS SYSTEM VOLTAGES

For Supplying Service Voltages 600 and Below								For Supplying Distribution Voltages Above 600							
Standard System Voltages	Standard Sizes for Each Voltage Class	Transformer High Voltage Ratings for Operation from Various Standard System Voltages					Transformer Low Voltage Ratings for Supplying Service Voltages 600 and Below	Standard Sizes for Each Voltage Class		Transformer High Voltage Ratings for Operation from Various Standard System Voltages					Transformer Low Voltage Ratings for Supplying Nominal 2300 or 4000-volt Distribution
	Oil Immersed Self Cooled	On Full Winding	Approximately on Taps 2½%	5%	7½%	10%		Oil Immersed Self Cooled	Oil Immersed Water Cooled or Air Blast	On Full Winding	Approximately on Taps 2½%	5%	7½%	10%	
2300	250 to 500 incl.	2200 **2300**	2145 2245	2090 2185	2035 2130	1980 2070	..to 220/110 (3-wire)..or to 220/440 or to 550 ..to **230/115** (3-wire)..or to **230/460** or to **575**								
4600	250 to 500 incl.	2200 4400 **2300** **4600**	4290 4485	2090 4180 2185 4370	4070 4255	1980 3960 2070 4140	..to 220/110 (3-wire)..or to 220/440 or to 550 ..to **230/115** (3-wire)..or to **230/460** or to **575**								
6600	250 to 500 incl.	6600 **6900**	6435 6730	6270 6555	6105 6385	5940 6210	.....to 220/440 or to 550 .....to **230/460** or to **575**	250 to 1000 incl.	500 to 2500 incl.	**6600**	6435	6270	6105	5940	.....to **2300/4000Y**
11000	250 to 500 incl.	11000 **11500**	10725 11215	10450 10925	10175 10640	9900 10350	.....to 220/440 or to 550 .....to **230/460** or to **575**	250 to 2500 incl.	500 to 5000 incl.	**11000**	10725	10450	10175	9900	.....to **2300/4000Y**
13200	250 to 500 incl.	13200 **13800**	12870 13455	12540 13110	12210 12765	11880 12420	.....to 220/440 or to 550 .....to **230/460** or to **575**	250 to 2500 incl.	500 to 5000 incl.	**13200**	12870	12540	12210	11880	.....to **2300/4000Y**
22000	250 to 500 incl.	22000 **23000**	21450 22425	20900 21850	20350 21275	19800 20700	.....to 220/440 or to 550 .....to **230/460** or to **575**	250 to 2500 incl.	500 to 5000 incl.	**22000**	21450	20900	20350	19800	.....to **2300/4000Y**
33000	250 to 500 incl.	33000 **34500**	32175 33640	31350 32775	30525 31915	29700 31050	.....to 220/440 or to 550 .....to **230/460** or to **575**	250 to 2500 incl.	500 to 5000 incl.	**33000**	32175	31350	30525	29700	.....to **2300/4000Y**

Note—Transformers having low voltage rating of 230/115 are arranged for series or three-wire service only. Transformers having low voltage rating of 230/460 are suitable for series or multiple service only.

Note—Standard Single-phase Substation Transformers for supplying nominal 2300 or 4000-volt distribution and having voltage ratings listed above will be designed for successful operation when excited on full winding at 5% above their rated voltage.

(Adopted Standard 5-30-1918.)

TABLE IV—THREE PHASE POWER TRANSFORMERS

STANDARD TYPES

Oil Immersed—Self Cooled
Oil Immersed—Water Cooled
Air Blast

Note.—The application of Air Blast Transformers should be confined to systems where the voltage does not exceed 25,000.

Oil Immersed—Self Cooled				Oil Immersed—Water Cooled or Air Blast			
300	1200	3750	15000	750	2500	7500	30000
450	1500	5000	20000	1000	3000	10000	
600	2000	6000	25000	1200	3750	15000	
750	2500	7500	30000	1500	5000	20000	
1000	3000	10000		2000	6000	25000	

Note.—See following Table for sizes that are standard for the various system voltages.

STANDARD FREQUENCIES

25 Cycles per Second
60 Cycles per Second

STANDARD SIZES, VOLTAGE RATINGS AND TAPS OF SUBSTATION TRANSFORMERS FOR THE VARIOUS SYSTEM VOLTAGES

					For Supplying Distribution Voltages Above 600				
Standard System Voltages	Standard Sizes for Each Voltage Class	Transformer High Voltage Ratings for Operation from Various Standard System Voltages		Transformer Low Voltage Ratings for Supplying Service Voltages 600 and Below	Standard Sizes for Each Voltage Class		Transformer High Voltage Ratings for Operation from Various Standard System Voltages		Transformer Low Voltage Rating for Supplying Normal 2300-volt Distribution
	Oil Immersed Self Cooled	On Full Winding	Approximately on Taps 5%	10%	Oil Immersed Self Cooled	Oil Immersed Water Cooled or Air Blast	On Full Winding	Approximately on Taps 5%	10%	
2300	300 to 1500 incl.	2200/3810Y **2300/4000Y**	2090/3615Y 2185/3785Y	1980/3430Y 2070/3585Y	.....to **220/440**....or to 550 .....to **230/460**....or to **575**					
4600	300 to 1500 incl.	2200Y 4400Y **2300Y** **4600Y**	2090 4180 2185 4370	1980 3960 2070 4140	.....to **220/440**....or to 550 .....to **230/460**....or to **575**					
6600	300 to 1500 incl.	6600Y **6900Y**	6270 6555	5940 6210	.....to **220/440**....or to 550 .....to **230/460**....or to **575**	300 to 3000 incl.	750 to 7500 incl.	**6600Y**	6270	5940	.....to **2300**
11000	300 to 1500 incl.	11000Y **11500Y**	10450 10925	9900 10350	.....to **220/440**....or to 550 .....to **230/460**....or to **575**	300 to 7500 incl.	750 to 15000 incl.	**11000Y**	10450	9900	.....to **2300**
13200	300 to 1500 incl.	13200Y **13800Y**	12540 13110	11880 12420	.....to **220/440**....or to 550 .....to **230/460**....or to **575**	300 to 7500 incl.	750 to 15000 incl.	**13200Y**	12540	11880	.....to **2300**
22000	300 to 1500 incl.	22000Y **23000Y**	20900 21850	19800 20700	.....to **220/440**....or to 550 .....to **230/460**....or to **575**	300 to 7500 incl.	750 to 15000 incl.	**22000Y**	20900	19800	.....to **2300**
33000	300 to 1500 incl.	33000Y **34500Y**	31350 32775	29700 31050	.....to **220/440**....or to 550 .....to **230/460**....or to **575**	300 to 7500 incl.	750 to 15000 incl.	**33000Y**	31350	23700	.....to **2300**

Note.—Transformers having low voltage rating of 230/460 are suitable for series or multiple service only.

Note.—Standard Three-phase Substation Transformers for supplying nominal 2300-volt distribution and having voltage ratings listed above, will be designed for successful operation when excited on full winding at 5% above their rated voltage.

Standard Three-phase Substation Transformers having voltage ratings listed above are not suitable for supplying 4000-volt distribution as such service would necessitate "Y" connection on both high and low voltage sides simultaneously and this connection may result in excessive stress in the windings due to harmonic voltages.

Note.—Voltage ratings in bold type will be considered the normal voltage ratings of these lines and guarantees will be made only on these normal voltage ratings. It is understood, however, that where a transformer is suitable for operation at two voltage ratings this flexibility will be definitely indicated on the name plate, on the connection diagram or on a paster inside the transformer cover.

Standard transformers having voltage ratings listed above will be designed for full rated kv-a. output at any specified tap voltage without exceeding guaranteed temperature rise.

(Adopted Standard 5-23-1919.) Published by the Electric Power Club.

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GENERAL ELECTRIC COMPANY

General Office: SCHENECTADY, N. Y.

Manufacturer of

Complete Electrical Equipment and Supplies

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*Southwest General Electric Co.

DISTRIBUTOR FOR GENERAL ELECTRIC COMPANY OUTSIDE OF THE UNITED STATES

INTERNATIONAL GENERAL ELECTRIC CO., INC.

GENERAL SALES OFFICES: 120 Broadway, New York; Schenectady, N. Y.

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Argentina: General Electric, S. A., Buenos Aires.
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Holland: Philips Gloeilampen Fabrieken, Eindhoven.
Hungary: United Incandescent Lamps and Electrical Co., Ltd., Ujpest, near Budapest.
India: British Thomson-Houston Co., Ltd., Calcutta and Bombay; International General Electric Company, Inc., Calcutta and Bombay.
Italy and Colonies: Compagnia Generale Di Elettricita, Milan; Fabbrica Lampade Itala, Milan; Societa Edison per la Fabbricazione della Lampade, Milan.
Japan: International General Electric Co., Inc., Yokohama; Shibaura Engineering Works, Tokyo; Tokyo Electric Co., Ltd., Kawasaki.
Mexico: Mexican General Electric Co., City of Mexico, Monterey, Guadalajara.
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Paraguay: General Electric, S. A., Buenos Aires, Argentina.
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Philippine Islands: Pacific Commercial Company, Manila.
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Russia: Wsesobshtchaia Electricheskaia Kompania, Petrograd and Vladivostok.
South Africa: South African General Electric Co., Ltd., Johannesburg and Capetown.
Spain and Colonies: Sociedad Iberica de Construcciones Electricas, Madrid and Barcelona.
Uruguay: General Electric, S. A., Montevideo.
Venezuela: Wesselhoeft & Poor, Caracas.

Products

The General Electric Company manufactures complete electrical equipment for mines, including that for generating and distributing power, electric motors and control for driving various machines about the mine and mill and still other electrical apparatus for supplying heat and light.

Many mine operators standardize on G-E electrical equipment. With all electrical apparatus built by one company, tested and assembled for operation, units are interchangeable and fewer renewal parts are required.

Where to Get G-E Products

Contact with users of G-E equipment is maintained through Sales Offices. It is directed from the General Office at Schenectady, N. Y., through branch offices listed above which embrace the whole country. Warehouses, conveniently placed, insure prompt deliveries.

G-E motor dealers, headquarters for standard motors and repair service, are located in every city and large town. Small G-E electrical devices are sold by electrical supply and appliance stores everywhere.

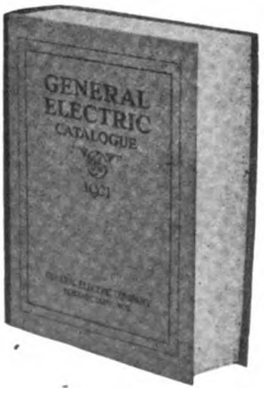
Engineering Service

The factories, engineers, and other facilities of the General Electric Company are at the disposal of all those in authority and responsible for the successful operation of mine equipment.

At each district office are specialists of the Company who are at your service. They give cordial co-operation to mine operators in need of information on electrical matters.

Descriptive Publications

To assist in the proper selection of G-E equipment and supplies, either new or for renewals, many G-E publications are available.



The General Catalog, distributed to users of G-E equipment, gives descriptions and data on practically all G-E products and, in some cases, prices and identification for ordering.

Special bulletins and leaflets give more detailed information on many subjects. They are readily obtainable upon request from G-E Sales Offices. Many of these are referred to by number in the following pages to help readers to secure additional information desired.

Supply Parts Bulletins and Renewal Parts Catalogs make it easy to order G-E renewal parts accurately and quickly and thus help you to maintain equipment with supplies made by the original manufacturer. The Renewal Parts Catalogs are specially compiled to cover G-E equipment in use.

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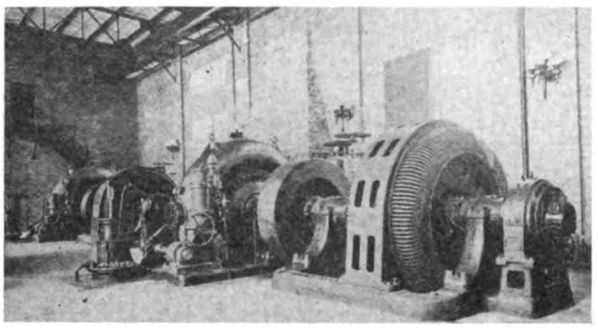
EQUIPMENT FOR ELECTRIC POWER SUPPLY

Hydro-Electric Station Equipment

This Company manufactures water-wheel driven generators ranging in capacity from 30 to 40,000 kv-a. Both the horizontal and vertical types are individually designed to meet most efficiently the various requirements imposed by the supply of water available and the operating conditions involved. Bulletin 40601 gives information on the 30 to 625 kv-a. sizes. Large installations are illustrated in Bulletin 40600.



Three G-E Water Wheel Driven Generators, Cleveland-Cliffs Iron Company, Ishpeming, Mich.

In addition to water wheel driven generators, complete G-E electrical equipment for hydro-electric stations is available and the service of the Company's engineers is at your disposal to assist in selecting apparatus.

Curtis Steam Turbine Generators

The Curtis steam turbine, as manufactured by the General Electric Company, is distinguished by its low cost of operation and reliable service. The exhaust steam from the turbine is free from oil and may be used for heating the boiler feed water, or for heating the building, or for other low-pressure purposes.

G-E Curtis turbines are built in sizes of from 10 kw. upward for d-c generators, and from 100 kw. upward for a-c generators. The turbine-generator sets are designed for continuous operation under the varying conditions of load found at mines.

Mechanical Drive Turbines—A special form of this turbine is widely used for driving centrifugal pumps, blowers and other like apparatus. It can be furnished with gears for medium and low-speed drives to insure speeds of both turbine and driven machine that give best efficiency.

G-E Flow Meters

The General Electric Company makes a complete line of flow meters for measuring the flow of steam, water, air, gas or oil through pipes.

G-E flow meters are built in several types for various classes of work. They do not require ideal surroundings and constant expert supervision to keep them operating. (Bulletin 46501.)

Automatic Station Equipment

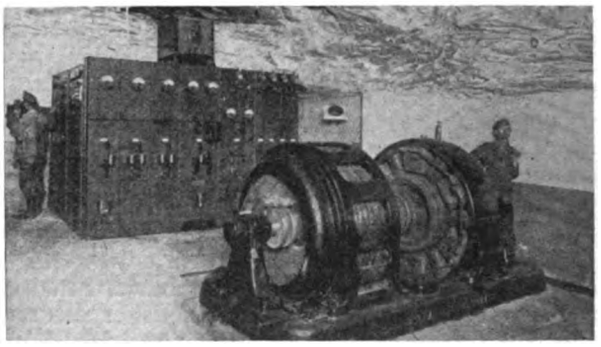
Automatic station equipment offers the most efficient and inexpensive means to obtain reliability of electrical service, which is of prime importance in mining and milling. It eliminates attendance, which is a large item of operating expense. G-E automatic switching equipment has proved successful for the control of synchronous converters and synchronous and induction motor generator sets and balancer sets in mining stations, steel plants, battery charging stations, and office buildings.

Automatic mining substations improve voltage regulation without excessive installation of feeder copper. The greatest practicable continuity of service is obtained, with best voltage at points where most needed, and the least slowing down of production during overload periods. The equipment automatically protects itself against damage from abnormal conditions that may arise during operation. (Bulletins 47730, 62501 and 67712.)

Mining Substation Equipment

The General Electric Company makes standard equipment for mining substations of two types, i. e., with motor generators or synchronous converters. Each type is standardized for four sizes, 100 kw., 150 kw., 200 kw., and 300 kw., the d-c. side being 275 volts. The motor generators and synchronous converters are designed for mine service, are highly efficient and capable of carrying 150% momentary overloads.

"Station layout" drawings have been prepared covering these equipments, these drawings giving the building dimensions, location of apparatus and a list of the cable, conduits, bushings, etc., required for the installation. This standardized equipment makes readily available a substation for use either above or under-ground and solves the power problem, especially for mine operators who purchase their electrical energy.



G-E Underground Substation Equipment, Republic Iron and Steel Company, Sayreton Mines, Ala.

This equipment is suitable for operation in the humid atmosphere of underground locations. It must be protected from submersion or from dripping water, however.

D-C. Reclosing Feeder Equipment

Automatic reclosing equipment is now available for 275-volt and 550-volt feeders. These are provided with a circuit breaker which opens on overload or short circuit and remains open till the overload or short circuit is removed. Then it automatically recloses. (Bulletin 47716.)

Belt Driven Generators

G-E belt-driven, d-c. generators are built in capacities from a fraction of a kilowatt to 300-kw. capacity, standard voltages.

The a-c. generators are designed for various frequencies and voltages, from 7½ to 550 kw.

Bulletins are available.

Steam Engine Driven Generating Sets

This Company manufactures steam engine-driven sets, with either a-c or d-c generators,

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in sizes ranging up to 60 kw. For mines buying their own power from power companies, it may be desirable to have a reserve installation. This need is satisfactorily met by a direct-connected generating set, which will operate in parallel with other units. (Bulletin 42300.)

Lightning Arresters

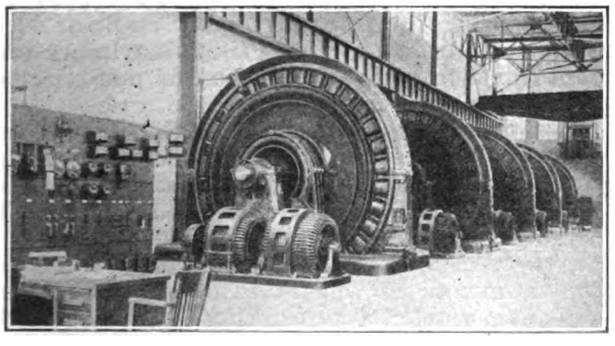
The extensive use of high-tension current about mines makes it necessary to provide ample protection against lightning in order that continuity of service and a minimum of operation and maintenance losses may be assured.

G-E lightning arresters are available for all needs. The oxide film type is for use on important a-c. systems of any voltage. Specially adapted for isolated stations and outdoor transformer installations. (Bulletin Y-1441.)

Smaller types are suitable for indoor or outdoor use, on feeders at receiving points, on motor circuits, or at the terminals of even the smallest transformers. Ask for special bulletins.

Synchronous Converters

For low-voltage industrial and electrolytic work the regulating pole or booster type, introduced by the General Electric Company, is recommended. By means of the booster the d-c. voltage can be varied 15% to 20% in either direction from the average. G-E synchronous converters are available for this service in capacity up to 8800 amp. Units for converting any small amounts of power can also be supplied. (Bulletin 62500.)



G-E Synchronous Converters, Anaconda Copper Mining Co.

Transformers

Transformers furnished for mine use are capable of withstanding rough treatment in transportation, as well as severe operating conditions. Reliability is the first consideration, and the many thousands now in service are evidence of ability to operate continuously with minimum losses and maximum factor of safety.

Distribution transformers in capacities up to 200 kv-a. are manufactured in standardized ratings and voltages, which have been carefully selected to meet all ordinary requirements.

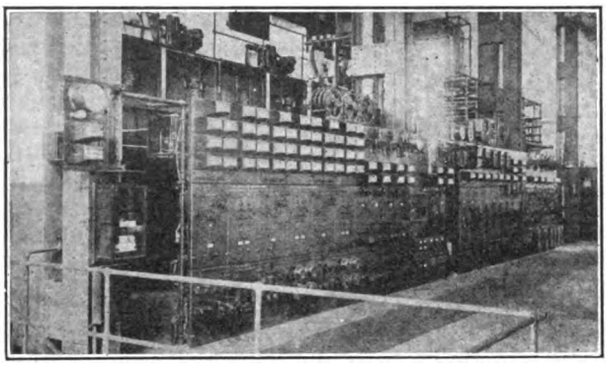
A standard line is built for service above and underground. "Specials" can be furnished for extraordinary service requirements. (Bulletin 45110.)

Small Transformers—The G-E line of small air-cooled transformers and auto-transformers ranges from 15 watts up to 25 kv-a, 600 volts and below. These transformers are made for either indoor or outdoor service and are adaptable to the operation of small, low-voltage motors or lights from higher voltage circuits, signal lighting, two or three phase transformation, etc. (Bulletin 65105.)

Switchboards

The General Electric Company offers a complete line of reliably and correctly designed switchboards for mine work. Prospective purchasers are invited to submit their proposed installations to G-E specialists, who will submit sketches and specifications covering equipment best suited.

Standard Unit Panels—These panels have been developed for voltages up to 1200 direct current and 3500 alternating current. They are so designed that they can be obtained in different combinations



Switchboard, Inspiration Consolidated Copper Company.

to form a complete switchboard. It is always advisable to use a Standard Unit Panel, because it is less expensive and can be secured in less time than special designs, though quality and workmanship are the same. (Bulletin 47001.)

Safety Enclosed Switchboards—Marked progress has been made in developing means which will prevent accidental contact with live parts, and this development has also increased the efficiency of operation by giving greater ease of inspection, adjustment and replacement. This Company has given much attention to this subject and has developed several types of safety panels which have proved very successful in service. (Bulletins 67105, 67100, and 67110.)

Switchboard Devices and Instruments

This Company is prepared to furnish with switchboards all of the equipment used in conjunction with them. This includes a-c. and d-c. relays of various types, air and oil circuit breakers, lever switches, and meters and instruments with instrument transformers and other accessories. These devices can be also obtained separately.

The G-E line of electrical instruments includes indicating and recording instruments, both switchboard and portable types, which are neat in appearance, substantial in construction, and unsurpassed in accuracy. Meters and instruments can be furnished for power plant use, for testing, and measuring currents in electrolytic work.

Insulated Wires and Cables

G-E insulated conductors include all types for the distribution of current for power and lighting in and about mines, armored cables, asbestos station cables, large cables for high-tension a-c. circuits, weatherproof and slow-burning cables, etc. Mines needing cables for use in wet places, where corrosion is to be feared, for direct burial in the soil, or for vertical support in mine shafts, will find standard designs for their needs.

Ask the nearest G-E Sales Office for descriptive bulletins, stating the kind of service you require.

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ELECTRIC LIGHTING SUPPLIES

Flood Lighting Projectors

Flood lighting projectors are coming more and more into use to facilitate night work, especially around electric shovels in open-cut mining. G-E projectors are the result of years of research and experience in manufacture. They are held in a water-proof casing, and supplied with either hinged base, swivel or trunnion base, or swivel and pipe-stand base. (Bulletin 43850B.)

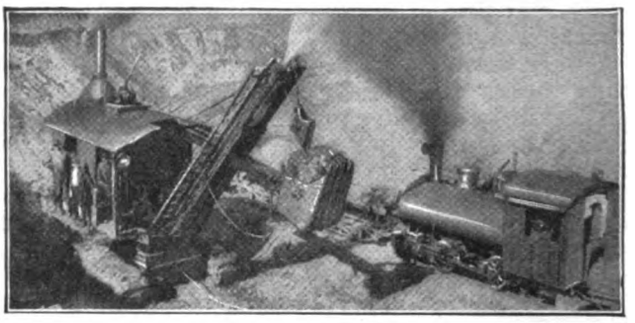
G-E Floodlight Projector

G-E Illuminating Engineering Specialists will prepare specifications and make recommendations on any lighting proposition, a service available at any time to mine officials.

Headlight Turbine Generator Sets

A 500-watt turbine generator set has been designed especially to supply power for headlights and cab lights. Its use has been extended to other applications, such as lighting around steam shovels, derricks, wrecking cranes, and drilling outfits.

The set consists of a single-stage Curtis steam turbine direct connected to a compound-wound generator which delivers energy at practically constant voltage under different loads. For industrial applications, it is made for operation on 70- to 170-lb.



Turbine Generator Sets on Locomotive and Steam Shovel Supplying Current for Headlight and Floodlights

or 125-225-lb. boiler pressure, supplying 110 or 32 volts. (Further details in Instruction Book 82014B.)

Wiring Supplies

G-E wiring devices meet every wiring requirement. They include porcelain and other weatherproof types especially adapted for outdoor wiring. They are used to a large extent for the lighting installations around mills, smelters, top works of mines, and at underground stations of the shafts. Send for Catalog Y-1270.

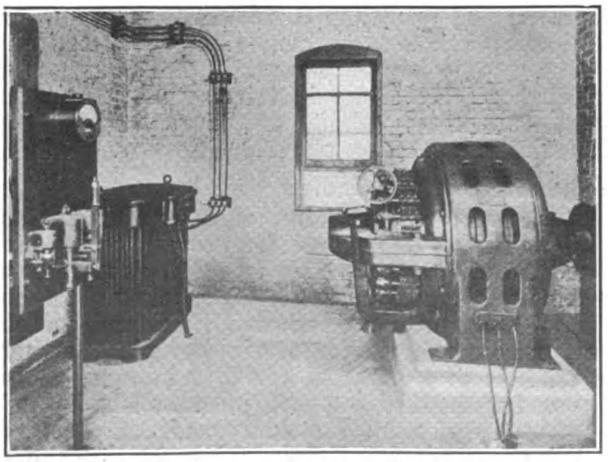
ELECTRICALLY DRIVEN MACHINERY—MINE AND MILL

Motor Drive for Mine Ventilation

Metal mine ventilation must be studied under two distinct systems: First, where the whole mine is considered as one ventilation unit, and second, where the ventilation is applied by a number of units, often widely separated. The problems of motor drive in the former case are the same as in coal mining in which G-E engineers have had many years' experience.

For the first system the constant-speed squirrel cage induction motor offers ideal characteristics.

The variable speed, induction motor has been widely applied and with entire success, save for the handicap inherent in the rheostatic control, i. e., a reduction in efficiency directly proportional to the reduction in speed. Consequently, the brush shifting commutator type a-c. motor marks an important advance in the application of motor drive to fan service.



100 H. P. Variable Speed a-c Motor Driving Fan

Another method applicable to variable speed induction motors involves the use of a polyphase commutator motor which returns the slip energy of the main motor to the system and gives a high efficiency over the entire operating range.

In the second system small blower fans are located at points convenient to power source and as close as possible to the working to be ventilated. Electric power has made possible this system of ventilation, which is used even in those mines where a large central unit is installed for the temporary ventilation of workings difficult to reach with the main current such as winzes and raises.

The motors to handle this class of work may be either a-c. or d-c., in many mines the current being taken from the trolley line. Motors must be made to withstand rough handling and operate efficiently with a minimum attention on temporary foundations in a humid and usually warm atmosphere. G-E motors have been successfully used in this work for years. Consult the nearest G-E Sales Office for assistance in solving your mine ventilation problems.

Mine Pump Motors

To meet rigid demands of mine pumping this Company has designed a special line of induction motors for direct connection to centrifugal pumps. As a protection against water and humidity, moisture resisting windings are used, enclosed in a rigid box type frame, and effectively cooled by self-ventilation. The motor is made more accessible for inspection by the use of split-end shields and bear-

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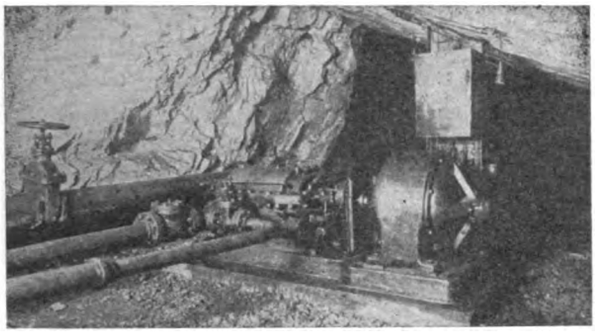
ings, while large bearing surfaces and oil wells make frequent examination unnecessary. Built in sizes from 75 to 400 h. p., constant speed and variable speed types. Control equipment for these motors can be supplied for either hand or automatic operation. (Bulletin 61301).

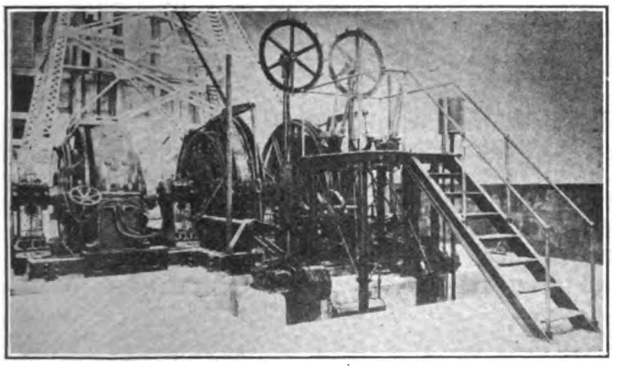


G-E Motor Driving Centrifugal Pump, Red Ore Mines, Tennessee Coal, Iron and Railroad Company

G-E vertical induction motors also have marked advantages for driving mine pumps. They are readily adaptable for installation in mine shafts or other convenient places, since the motor can be located at any convenient height above the pump.

Electric Mine Hoist Equipment

The use of electricity for operating hoists in mining districts is rapidly increasing. Particularly is this true in shaft mines and in localities where material must be carried across ravines on cableways. The economy of electric mine hoists has been so clearly demonstrated that many large companies have found it profitable within recent years to scrap all steam mine hoists and replace them with electric outfits. Electric hoists have also a superior speed control, they are simpler in operation, they have a smaller number of parts, and they are lighter in weight, more compact and more flexible.



200 H. P. G-E Motor Driving First-Motion Hoist, Silver King Coalition Mines Company, Park City, Utah

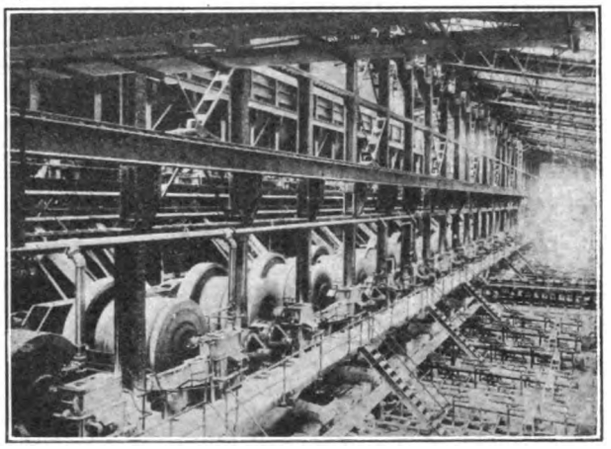
G-E mine hoist motors are the result of years of experience in applying many types for operation under all conditions. Complete control equipment can be furnished with each motor, either for hand control or for automatic hoisting. Bulletin Y1111 gives a partial list of G-E installations and also an outline of the data required for estimating equipment needed.

Motors for Driving Mill Machinery

Mill machinery today is very largely driven electrically because greater economy, as well as extreme flexibility, is obtainable. The motors are belted or geared, but direct-connected when the speeds are comparatively high. Some of the many applications in mill work are: Driving crushers; grinders; conveyors and elevators; concentrating devices, such as jigs and tables; screens and flotation machines; mechanical classifiers and thickening tanks. The motors used in mill work must be so constructed as not to require too much attention and in spite of adverse conditions, such as moist and gritty air.

Crushers and ball and tube mills require heavy duty motors with high starting torque, because the starting load is often nearly double the running load. Scores of successful G-E installations, large and small, for leading mining companies testify to the splendid operation of these motors.

Electric drive has made possible the present extensive use of all forms of conveyors and elevators. These have been instrumental in reducing milling costs and in making possible the modern form of



Concentration Mill, Inspiration Consolidated Copper Co., with a G-E Motor Driving Each of the 40 Marcy Mills

concentrating mill and metallurgical plant. G-E equipment is available for driving conveyors of any size for either constant or adjustable speeds, as well as for the operation of all forms of trippers.

The General Electric Company was first to adapt vertical motors to the direct drive of mechanically agitated flotation machines, co-operating with the machine manufacturer. The successful operation of the original installation over a period of years as well as of numerous other similar installations attests to the suitability of this G-E equipment.

Centrifugal Blowers

The G-E Centrifugal Blower or Centrifugal Compressor is designed for large volumes and low pressures, such as are required for the operation of blast furnaces, powdered coal firing, ore flotation plants, copper converters, cupola blowing apparatus and other equipment.

An inherent characteristic of the blower is its ability to deliver practically constant pressure over a wide range of loads. This is of particular advantage when the blower is supplying air to a battery of oil or gas fired furnaces, some of which may be shut down at times.

The blower and driver being direct connected, means the minimum number of bearings, and eliminates countershafts and other fixtures inherent in belt or chain drive. It also eliminates much lubri-

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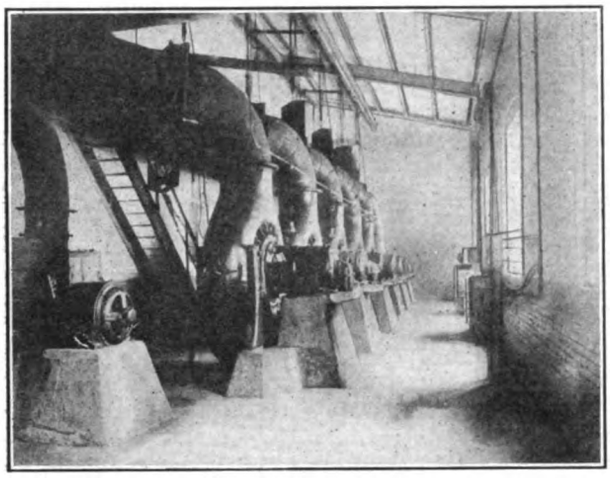
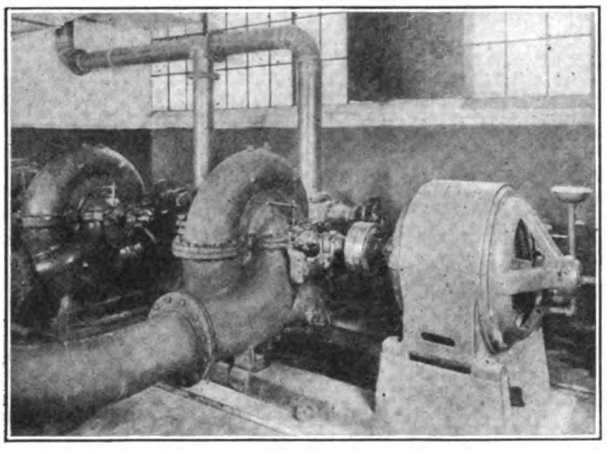
cation. The dimensions are small, so that small floor space is required. (Bulletin 48609).



G-E Motor Driven Compressors, Washoe Reduction Works, Anaconda Copper Mining Company

Motor Drive for Mill Pumps

Pumps used in mill work for pumping water, solutions, ore pulps, etc., give rise to many different problems in motor drives. The extensive experience of the General Electric Company in solving these problems in consultation with mill men gives assurance of the correct solution of your problem.



G-E Induction Motors Driving Pumps for Mill Water Supply

Electrically Driven Dredges

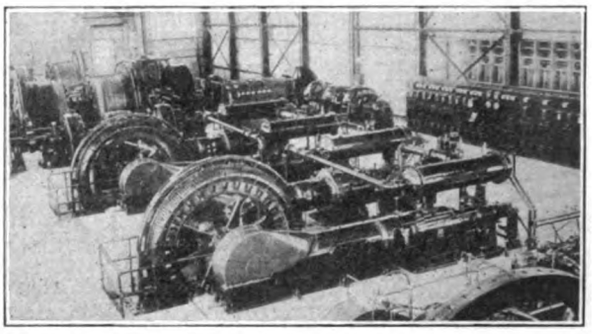
Because of the fire risk attendant upon the use of steam and the greater flexibility and usually lower cost of electrical power, most of the modern dredges are electrically driven. Motors for this work must be very strong to withstand the heavy service to which they are submitted. The motor attached to the digging ladder must, especially, have a high overload factor to overcome excessive strains when anchored boulders are encountered.

The experience of the General Electric Company in outfitting some of the largest dredges recently put into commission, as well as many of the smaller ones enables it to recommend the best equipment, both as to motors and control, for this purpose. Consult the nearest G-E Sales Office.

Electric Drive for Air Compressors

The air compressor is the heart of the modern metal mine of any size, as well as of many rock quarries. The amount of drilling done for blasting is dependent upon a constant and sure supply of air, and on the amount of rock drilled and blasted depends the output of the mine.

Air compressors lend themselves readily to drives by means of direct connected synchronous motors, especially the larger units. For belt, gear, or rope-driven types, the induction motor is used, as well as for direct drives of small compressors.



G-E Synchronous Motors Driving Air Compressors, Inspiration Consolidated Copper Co., Miami, Ariz. Electrically Driven Automatic Hoist in Background

Synchronous motors are particularly desirable when power is purchased at a rate which is dependent upon the power factor of the load.

G-E synchronous motors cover a wide range of speeds and capacities. The nearest G-E Sales Office will give you further information.

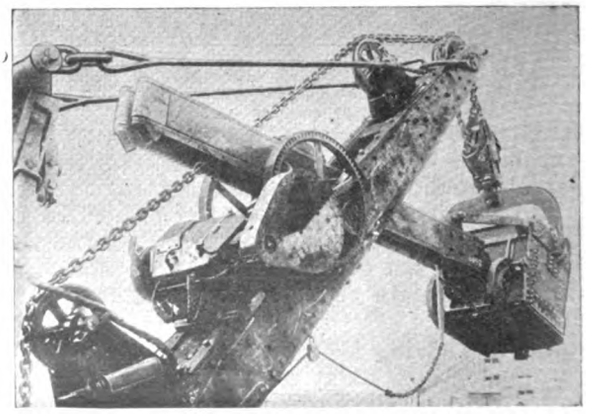
Electrically Driven Air Compressors

Portable Air Compressor

It is often desirable to obtain small amounts of air where a permanent compressor plant would not be justified. This Company has adapted its small reciprocating compressors, such as are used to supply air brakes on electric railways, for operating pneumatic tools in the repair shop or for underground drilling. Being self-cooled rather than water-cooled, this machine has a decided advantage. These compressors are built as a unit with either induction motors or d-c. motors, and are furnished complete, either stationary or portable. (Bulletin 48610.)

Electric Shovel and Locomotive Crane Equipment

The electric shovel is a new development, the possibilities of which are being recognized more and more by quarrying and mining companies. The present high prices of coal, shortage of labor, and general need of economical and increased production are causing progressive companies to adopt



Crowding Motor and Controller on a 65-Ton Electric Shovel Equipped with Four G-E Motors

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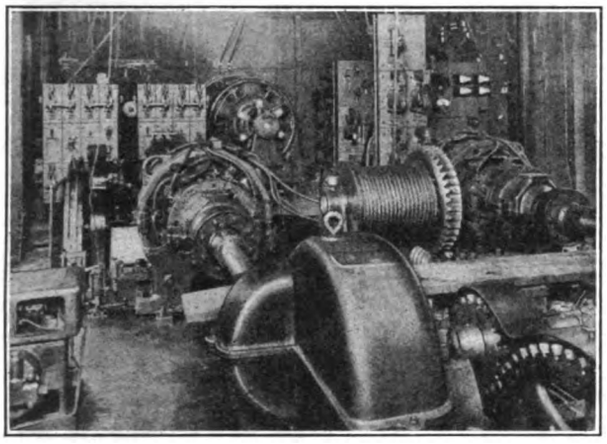
large electrics in preference to steam shovels to increase the efficiency of their operating systems.

The success of the larger shovels in stripping has led to their development in other fields, such as excavating and loading ore directly into the dump cars. For this work they are especially applicable, due largely to the greater amount of material within reach of the large shovel at one setting.



G-E Motors and Control on 300-Ton Electric Stripping Shovel

The General Electric Company has furnished complete electrical equipment for some of the largest shovels now in operation. This machinery consists of motor generator sets, motors for hoisting, swinging, crowding and tripping, together with a variety of control equipment. G-E series direct current motors are furnished for this service in conjunction with differential wound generators with voltage control. Progress is constantly being made in the perfection of electrical control for shovels which is destined to make their advantages even more significant in the future.

Explain your needs to the nearest G-E Sales Office.

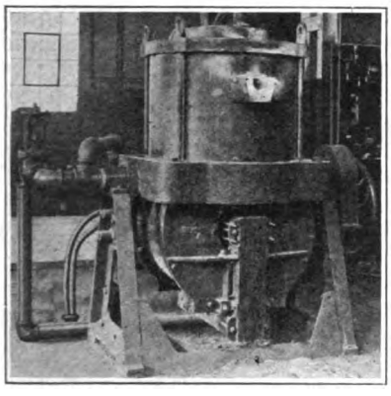
Aerial Tramways and Cableways

This is another field in which electric drive has recently made rapid advancement. One reason for this is that electric power lends itself so readily to automatic or semi-automatic control. In digging or loading, cableways dumping at a fixed point or points, can be made absolutely automatic, reducing the labor costs and speeding up the work. In tramway work, especially with continuous types, electric drive reduces the power consumption and gives steadier operation. Consult G-E engineers on new construction or electrification of your present installation.

ELECTRIC FURNACES AND EQUIPMENT IN METALLURGY

Electric Melting Furnaces

For melting non-ferrous metals and alloys, the General Electric Company has developed two types of furnaces, the muffled arc type and the induction type. In general the muffled arc furnace is suitable for intermittent service in small foundries, whereas the induction furnace finds its field in larger foundries and rolling mills where the melting operation is more or less continuous and the production is of large volume.

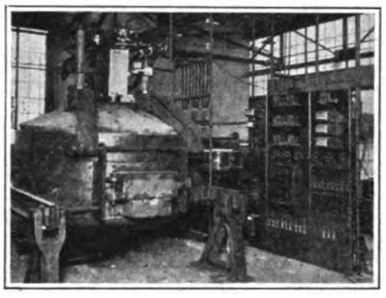


75 kw. G-E Repulsion Induction Furnace

The induction furnace is a new development and combines in itself all the characteristics and advantages of this type of furnace, together with several new features such as preformed linings and automatic uni-directional circulation of the metal. These features are of extreme importance, as they directly affect the quality of the product and the cost of operation.

Both types of furnace are very efficient and economical to operate. They will produce metal of the highest quality with the minimum loss of volatile alloys. Furnaces are supplied complete with all electrical equipment and accessories, and are built in various capacities to meet the needs of the industries. (Bulletins 69710 and 69711.)

The G-E horizontal ring type induction furnaces are principally for the refining of steel, cast iron and malleable iron of high quality.



1500 lb., 250 kv-a. Non-Ferrous Melting Electric Furnace

Other uses are the reclamation of expensive alloy steel, and the melting of ferro - manganese preparatory to alloying steel in the liquid state.

Consult G - E furnace specialists for detail information concerning these furnaces and their application.

Arc Furnace Equipment—This Company manufactures also electrical equipment for any type of electric arc furnace. Designers of furnaces for reduction of ores, for producing ferro-alloys, electrolysis, and a multitude of other electrothermic developments, will find the General Electric Company's experience in this line of value. (Bulletin 48710.)

G-E furnace specialists will co-operate in the proper design of furnaces from the electrical engineering point of view, advising as to latest improvements in electrical equipment and as to the best utilization of the sources of energy available.

Electrical Precipitation Equipment

The General Electric Company is prepared to furnish all of the electrical equipment for the Cottrell Electrical Precipitation Process. This equipment, which includes transformers, motor generator sets, synchronous motors, switchboards, and rectifying apparatus, is of a very special type.

Bulletin 49137, giving further information on the electrical equipment furnished for this service, will be sent on request.

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ELECTRICAL SHOP EQUIPMENT

Repair Shop Motors

Various G-E motors are suited for use in the mine repair shop. The Type RF adjustable-speed d-c. motor is extensively used for driving machine tools and similar service where wide variation of speed is required independent of load. It is made in sizes from 2 to 50 h. p. Starting and controlling equipment can be furnished for either light or severe service. (Bulletin 48029.)

Fractional Horsepower Motors—This Company has studied extensively the problems of electric motor application to small tools, and out of this study has evolved a line of small motors of sizes from 1/200 h. p. upward. These can be furnished in a-c. or d-c. types, built in the same frames and mechanically interchangeable. The accompanying illustrations show two of the several applications of these motors for shops in the mining field.

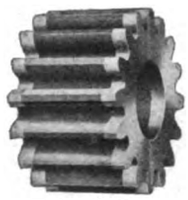
Portable Drill

Grinding Machine

The machines are not built by the General Electric Company, but G-E motors can be incorporated in them by specifying G-E Motors from the machinery manufacturer.

Fabroil Gears

G-E Fabroil Gears are made from cotton to give noiseless operation, have a high tooth strength, and whether in the wet, rat-infested workings of a mine or in the dry clean power plant at the top, work equally well. They serve on motor-driven pumps, hoists, machine tools, and similar machinery, meshing with cast iron, steel or bronze and reducing wear on the metal gears. (Bulletin 48703.)



Fabroil Gear

Insulating Compounds and Fabrics

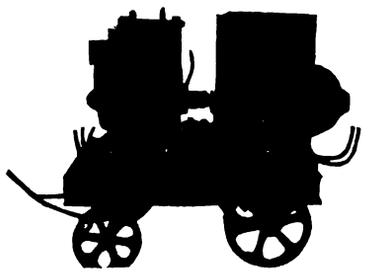
The insulating materials—compounds and fabrics—manufactured by the General Electric Company have been developed primarily to meet the requirements of its own products. These materials are offered to mine operators and others for electrical repair work.

G-E insulating compounds include varnishes, japans, oils, sealing compounds and paints. The fabrics include fibers and papers, treated with varnishes, oils, and japans, and also asbestos tape and treated cloths. Write the G-E Sales Office nearest you for prices or other information.

Electric Arc Welding Equipment

The use of welding apparatus by foundries, steel mills and repair shops for the manufacture and repair of metal parts is rapidly increasing, due to the economies effected. This Company has developed several types of arc welding equipment designed to meet almost every condition where it is possible to join metals by means of the electric arc.

For general use, both single and multi-operator motor generator sets are available primarily for metallic electrode welding. They can be used with carbon electrodes for cutting, which affords a very fast and practicable way of cutting or trimming castings, or the plates of steel cars. The generator can be driven by any standard form of power. (Bulletin 48932.)



Single Operator Arc Welding Set

The G-E Automatic Welder is especially applicable for routine duplicate welding of seams and worn or undercut shafts, axles and plates. It eliminates the unsteady conditions incident to manipulating the electrode by hand and makes a better weld in 20 to 50 per cent. of the time required.

A Semi-Automatic Welding Lead, for use with the G-E Automatic Welder, permits the operator to direct the arc as required, and thus weld seams of irregular contour readily; it also can be used for filling up blow holes in castings, or building up worn spots. (Bulletin 68909.)

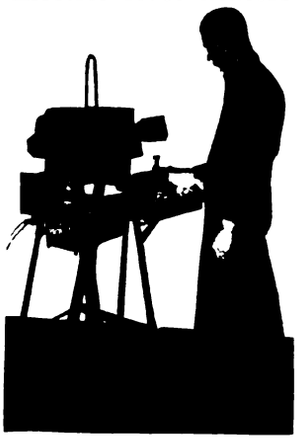
The use of G-E automatic and semi-automatic welders does not require highly skilled operators.

Resistance Type Welder—Strength, durability and low cost of operation are some of the qualifications of the type AW Resistor arc welder, specially designed for the welding of rail bonds, fish plates, etc., where it is not practicable to operate the more efficient outfits. In mines this equipment can be hooked to a trolley wire, and it can be carried easily to the job which your welder can do in quick time at a minimum cost. (Bulletin 68902.)

Electric Heating Equipment

The General Electric Company is constantly developing new equipment, necessitated by the increased use of electric heat in industrial operations. G-E industrial heating apparatus is being successfully applied in many different processes. It includes equipment for ovens and furnaces, small devices such as glue pots, and soldering irons and heating units for various applications. Engineers designing installations in which electric heating equipment can be used should avail themselves of accumulated knowledge and experience in this line. Specialists in this work are located in various G-E Sales Offices.

Electric Rivet Heaters—Electric rivet heaters are very useful in connection with the repair of steel plate cars and, around the mills for riveting steel tanks, etc. The electric heater possesses many advantages over fuel fired methods, such as portability, economical operation in power used and in successful heating, elimination of fire hazard, etc. The power consumption of the G-E electric rivet heater varies from 17 to 20 kilowatt hours per hundred pounds of rivets, depending upon the size and composition of the rivets. (Bulletin 69701.)



Electric Rivet Heater

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GENERAL ELECTRIC COMPANY

General Office: SCHENECTADY, N. Y.

D & W Fuse Division of General Electric Company Bridgeport, Conn.

D & W Wire Division of General Electric Company Schenectady, N. Y.

Fuses and Insulated Wires

Products

D & W Fuses; D & W Fuse Accessories; Deltabeston Insulated Wires.

D & W Fuses

The soundest engineering principles have been incorporated in the design of each individual fuse, and the closest attention is given to all details in their manufacture. The result is a fuse that is **accurate** in operation and that **protects** equipment under the most exacting conditions.

D & W Fuses Arranged from 3 to 1000 Amp. Capacity

D & W Fuses have protected electric circuits for years—service switches and fuse boxes since 1897—and they have met the most severe tests. The use of jiggs, templates and gages reduces the variable element to a minimum and secures perfect alignment, reliability and exact uniformity.

Use D & W Renewable Fuses for lines where the percentage of blowouts is high, and D & W Standard Fuses for the ordinary installations. Sizes range from 3 to 1,000 amp., for standard voltages.

D & W Waterproof Service Switch Box

Fuse Accessories—D & W Fuse Accessories include Enclosed Fuse Cutouts, Cutout Bases, Fuse Boxes, Fuse Links and Clips, Service Switches, Telephone and Telegraph Protectors, etc. The same quality of workmanship and material enters into these devices as is found in D & W Fuses and other D & W products. A complete line of outlet hoods is available to connect D & W Fuse Boxes with conduit systems. D & W service switches and fuse boxes are equipped with rubber gaskets, which render the cast iron boxes waterproof. The cover is held shut by a special, easily operated latch.

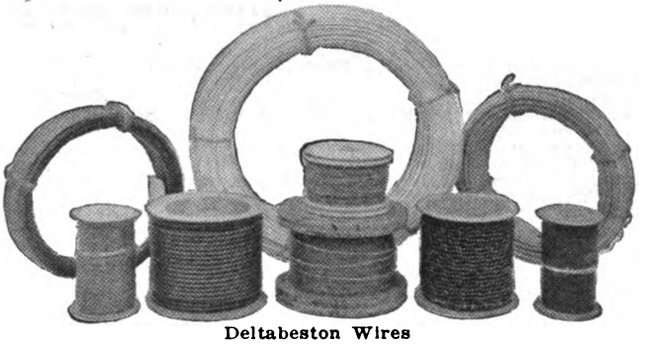
In D & W Enclosed Fuse Cutouts, ferrule type, permanent spring clips of phosphor bronze are used. In the knife blade type particular attention is given to lining up the blades, insuring perfect contact when a fuse is installed.

Further information is given in Catalog 6003, which will be mailed on request.

Deltabeston Wires

All Deltabeston Wires are asbestos insulated. Hence, any form or variety will give practically permanent service when subjected to heat. After the insulation has been applied to the wire, in all but two types, the asbestos is filled with a compound, which renders the finished product vapor-proof as well as heat-proof. Furthermore, experience has demonstrated that Deltabeston Wire will stand many kinds of fumes, which also makes it of particular value in mining work.

Deltabeston Magnet Wire is used chiefly for winding coils in motors which run hot, either because they are overloaded, or because of their location with reference to external heat or humidity. Motors wound with Deltabeston Magnet Wire very rarely break down under the severe operating conditions in the mining industry. Some of the well-known manufacturers of mining locomotives use it regularly in the manufacture of their motors. The insulation, asbestos fibre applied to the wire in a felted form and then impregnated, is of approximately the same wall thickness as double cotton



Deltabeston Wires

covered magnet wire. Round wire can be furnished in sizes from No. 3/0 to No. 20, and rectangular and square in practically all sizes smaller than .5x.25 in.

Deltabeston Fixture Wires and Heater Cord—Type A Heater Cord is a flexible conductor, insulated with the standard 3/32-in. wall of felted asbestos, and finished with an impregnated asbestos braid. The completed product is a flexible cord, extremely tough and resistant to abrasion, and heat and moistureproof. It is recommended for the exposed wiring of electric mining locomotives, for drop cords, and for more or less permanent wiring in a mine.

Deltabeston Motion Picture Cable is used for wiring on cranes, controllers, and searchlights, as well as motion picture apparatus.

Deltabeston Switchboard Wire is a solid conductor insulated with a 3/32-in. felted wall of asbestos fibre and finished with a hard outer asbestos braid. This wire is heavily impregnated, and because of its construction makes a practically permanent wire for use in connection with low voltage switchboards

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*Service Department Repair Shops.

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Atlanta, Ga., Gilham Schoen Electric Co.
Birmingham, Ala., The Moore-Handley Hardware Co.
Bluefield, W. Va., Superior Supply Co.
Buffalo, N. Y., McCarthy Bros. & Ford
Butte, Mont., The Montana Electric Co.
Charlotte, N. C., Carolina State Elec. Co.
Chicago, Ill., Illinois Electric Co.
Cincinnati, O., The Johnson Elec. Sup. Co.
Cleveland, O., The Erner Electric Co.
Denver, Colo., Mine & Smelter Supply Co.
Detroit, Mich., Commercial Elec. Sup. Co.
El Paso, Texas, Mine & Smelter Supply Co.
Evansville, Ind., The Varney Elec. Sup. Co.
Houston, Texas, Tel-Electric Co.
Huntington, W. Va., Banks Supply Co.
Indianapolis, Ind., The Varney Electrical Supply Co.
Jacksonville, Fla., Pierce Electric Co.
Kansas City, Mo., Satterlee Electric Co.
Los Angeles, Calif., Illinois Electric Co.
Louisville, Ky., Tafel Electric Co., Inc.
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San Francisco, Calif., Electric Rwy. & Mfrs. Supply Co.
Scranton, Pa., Penna. Elec. Eng. Co.
Seattle, Wash., Fobes Supply Co.
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Winnipeg, Man., 158 Portage Ave. E.
Toronto, Ont., 366 Adelaide St. W.
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New York Office, 165 Broadway
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Argentine, Cia. Westinghouse Electric Internacional, Maipu 73, Buenos Aires
Brazil (Southern), Byington & Co., Rua do Commerico No. 4 Caixa Postal P.
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Chile, Errazuriz, Simpson & Co., Huerfanos 1112 Santiago, Pratesq., Chile
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Guatemala, Emilio Selle, 10 Calle Oriente Numero 2, Guatemala City
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PARTIAL LIST OF PRODUCTS

Battery Charging Equipment.
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Brakes—Air and Magnetic.
Circuit Breakers.
Coils—Armature & Field, Choke.
Condensers—Synchronous, Jet, Barometric and Surface.
Controllers—Motor.
Converters—Booster.
Electric Furnace Equipment
Electric Furnaces—Drying, Baking, Enameling, Heat Treatment, Annealing, Glass, etc.
Fans.
Flood Lights.
Frequency Changers.
Fuses.
Fuse Blocks and Boxes.
Gears and Pinions—Metal and Bakelite.
Generators—D. C. and A. C., Engine, Turbine and Water Wheel.
Grid Resistors.
Headlights—Mine Locomotive.
Heaters—Air.
Heating Devices for Industrial Uses.
Instruments—Ammeters, Voltmeters, Wattmeters, Recording, Portable, Frequency, Power Factor.
Insulating Materials—Oil, Tape and Treated Cloth.
Lamps—Arc and Incandescent.
Lighting Reflectors and Fixtures.
Lightning Arresters.
Line Materials.
Locomotives—Storage Battery, Trolley and Combination.
Meters.
Micarta.
Motors—Synchronous, Induction, Fractional, Small-Power, Hoist, Pump, Flotation, Conveyor and General Mill and Mine.
Motor Generators.
Panels—Switchboard and Safety.
Power Plant Equipment.
Radio Equipment.
Rail Bonds.
Rectifiers—Mercury, Arc.
Rectigons.
Regulators — Furnace, Voltage, and Step Induction.
Resistance Coils.
Resistance Grids.
Resistors.
Rheostats.
Soldering Compounds.
Starters—Hand and Automatic.
Stokers—Overfeed, Underfeed and Chain.
Switches—Knife, Oil, Safety.
Switchboards.
Synchronous Converters.
Terminals.
Tools—Portable Electric.
Transformers—Furnace, Power, Distribution and Instrument.
Turbines—Steam.
Voltage Regulators.
Water Wheel Generators.
Welding Outfits — Stationary and Portable.
Wiring Devices.

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POWER PLANT EQUIPMENT

General

The Products of the Westinghouse Electric & Manufacturing Co. comprise almost every kind of apparatus and machinery used in the generation, distribution and utilization of electrical energy, as well as stokers and other mechanical equipment.

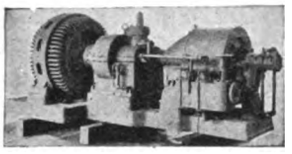
Service

Westinghouse engineers, through many years of practical experience in handling a great variety of problems, are able and willing to render the advice and assistance you need in your electrical problems.

Steam Turbine Generator Units

Westinghouse Steam Turbines of the reaction or Parsons Type can be supplied in any capacity for either condensing or non-condensing service.

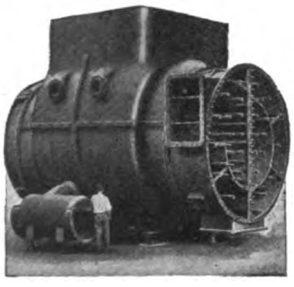
The accumulated experience of Westinghouse engineers covers the designing of numerous turbine-generator power installations ranging in size from 70,000 kw. down to 1 kw.



300 K.W. A.C. Condensing Type Turbine Generator Unit

Condensers

Westinghouse Leblanc Condensers are offered in three different types—surface condensers, jet condensers and barometric condehsers. They cover the entire line of applications of condensers to prime movers, the type recommended depending upon the local conditions. They have been manufactured and applied to turbines of all capacities up to 100,000 H. P.

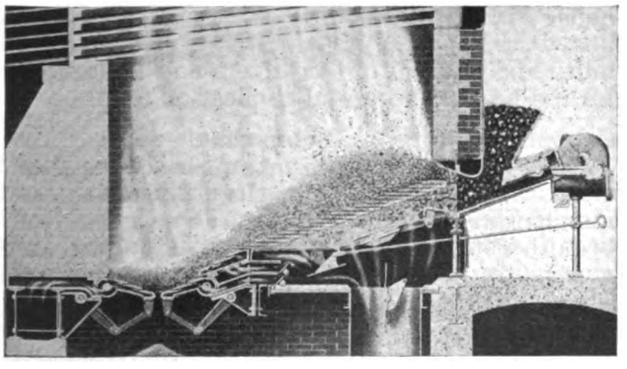


Large Surface Condenser

Stokers

There are three types of Westinghouse Stokers: The Roney, the Underfeed and the Chain Grate. This gives a type which will be suitable for every local condition.

The Roney Stoker is one of the overfeed type and is particularly adapted to tubular boilers and for purposes of the moderate-sized plant.



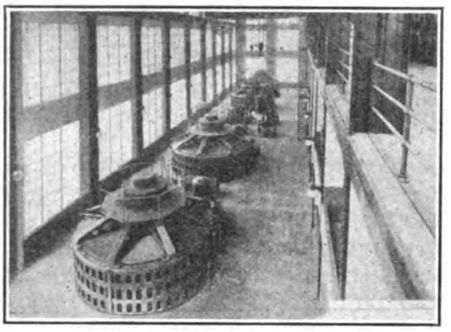
Underfeed Stoker

The Underfeed Stoker is of the multiple retort type. This stoker is especially desirable where sudden increases of steam demands must be met. It requires forced draft which can be obtained from Westinghouse Blower installations.

The Chain Grate Stoker is of the traveling grate type and gives excellent results where the loads are moderate.

Water-Wheel Generators

The first hydro-electric plant in America was equipped with Westinghouse equipment and is still in successful operation. Since that date Westinghouse engineers have designed many and varied hydro-electric installations and the accumulated expeperience of the Company in this line is at the service of those interested in hydro-electric developments, small or large, in connection with mines, mills or smelters. Westinghouse is prepared to build water-wheel driven generators of any capacity from 50 to 50,000 kv.a.



Water Wheel Generators

Belt-Driven Generators

Belt-driven Generators can be furnished for direct current in sizes from a fraction of a kilowatt to 1000 kw. in standard voltages. For alternating current, in capacities from 25 to 312 kv.-a.

Engine-Driven Generators

For alternating current, furnished in capacities from 62.5 to 1750 kv.-a. They are suitable for direct connection to steam, gas or oil engines and slow speed water-wheels. The D. C. types are furnished for various voltages in the same capacities as the belt-driven types.

Lightning Arresters

Westinghouse supplies a complete line of lightning protection equipment suitable for protecting all kinds of transmission lines from both atmospheric, lightning and internal surges. This equipment includes many forms of spark gap, electrolytic and horn-type arresters suitable for heavy service.

Distribution Transformers

Westinghouse distribution transformers are designed on the theory that safety, reliability, and durability are the most important characteristics that distribution transformers should have, because it is these qualifications which provide against interruptions of service, make for long life and protect the apparatus which is connected to the low-voltage circuits.

Group of Steel Clad Type S Transformers

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Power Transformers

Furnished in self-cooled, OISC, and water-cooled OIWC types. The self-cooled transformers provide for cooling by three types of construction: The boiler iron tank; the corrugated cast-in tank and the radiator type. The first is used for small capacities, the second for the intermediate and the third for the largest. The self-cooled types are made for all capacities and voltages. They are wound for single and three-phase service and can be supplied for any frequency desired.

Beyond a certain size, the water-cooled type is commonly used. They are built for any capacity above 200 kv.-a. and for any voltage, phase or cycle.

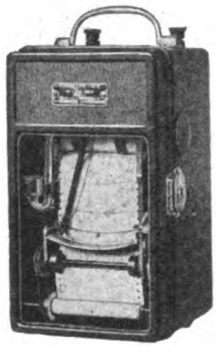
Switchboards

The Westinghouse Company manufactures a full line of switchboards for all systems of electrical distribution.

Westinghouse Switchboards, by the use of 7 inch meters and remote control oil breakers, require a minimum amount of floor space. The front of the board is entirely symmetrical and all indicating meters match perfectly in appearance. A complete line of standard panels is listed for prompt shipment. Where standard panels cannot be used, our engineers will be glad to be of assistance on special propositions, if the matter is taken up with our nearest district office.

Switchboard Instruments

A complete line of switchboard indicating instruments is furnished for every need. For direct-current circuits, ammeters and voltmeters 2 9/16, 3, 4⅜, 5 and 7 inches in diameter, and for all standard commercial circuits are furnished. For alternating-current circuits there is a complete line of ammeters, voltmeters, wattmeters, power factor meters, frequency meters and synchronoscopes, all 7 inches in diameter, for standard commercial circuits.



Type U Graphic Instrument

A complete line of recording instruments are furnished in both switchboard and portable designs.

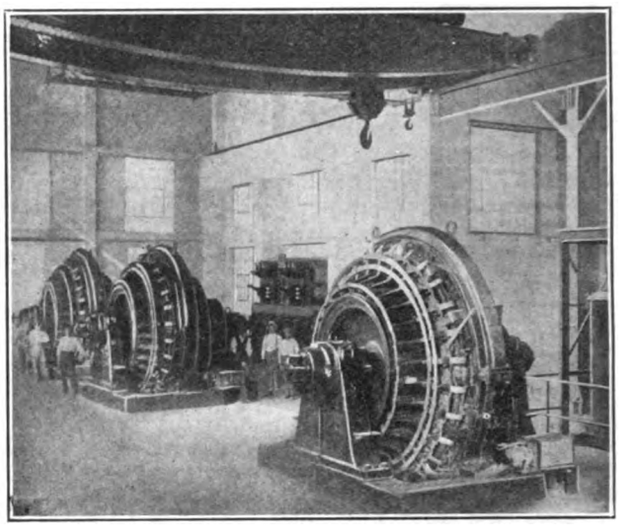
Also a complete line of instrument transformers, both portable and fixed, for inside and outside service.

Synchronous Converters

Direct current is required in the metal mining and the metallurgical industry in rapidly increasing amounts. This is because of the increase of electrical haulage and the extremely rapid growth of electro-deposition in the various leaching processes and in copper, lead, gold and silver refining. Either synchronous converters or motor-generator sets are used to obtain this form of energy from alternating-current supply circuits.

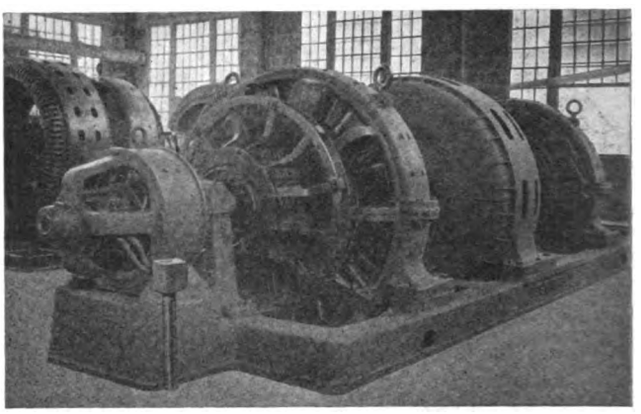
Synchronous converters commend themselves for this work on account of their high efficiency and other inherent characteristics. They are unequalled for their simplicity, strength, ruggedness, compactness, and exceptionally high capacity with a minimum of floor space.

Over one and three-quarters million kilowatts of converter capacity in successful operation all over America under widely varying conditions affords abundant evidence of the extent to which they are used.



Synchronous Booster Converters

Standard synchronous booster converters are wound for 270 volts, with a range of 240 to 300 volts D. C. for the usual converter ratings of 500 kw. and above, both for 25 and 60 cycles.



Synchronous Motor-Generator consisting of two 1000-kw, 185/70-volt 6000-ampere direct-current generators direct-connected to 3150-h.p., 2200-volt, 60-cycle, 3-phase, synchronous motor furnishing current for the electrical deposition of copper in the Tacoma Smelter, Tacoma, Washington.

Motor Generators

These are sometimes used in place of synchronous converters for converting alternating into direct current for mine and other uses. They combine the usual features of standard Westinghouse apparatus, such as the ability to withstand heavy overloads, ruggedness, economy and reliability and in event of converters not being used will form a highly successful application.

Cottrell Precipitating Equipment

The Westinghouse Company has furnished the electrical equipment for a large percentage of the installations now in operation. The equipment has been thoroughly standardized, and standard sizes of generators, transformers, etc., can be obtained.

Electric Furnaces and Ovens

The use of electricity for the production of heat in various industrial processes is rapidly increasing and its advantages, as compared with the use of coal, gas and oil, are so great that the older methods of heating are being rapidly superseded.

There are many applications in the mining industry where electric furnaces of the arc and induction types will undoubtedly be utilized.

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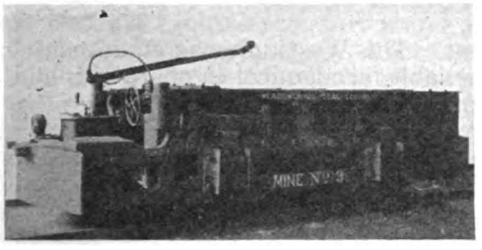
Westinghouse is prepared to furnish complete electrical equipment for the operation of such furnaces, including furnace transformers, winch motors, automatic electrode control, switchboards and incoming line and protective equipment.

For medium temperature requirements, Westinghouse has a complete line of Hevi-Duty furnaces of the muffle and crucible types, which have a maximum operating temperature of 2000° F. This is a resistance type of furnace and is subject to very accurate temperature control. This feature, coupled with its high temperature, should make it particularly suitable for many mining and smelting operations.

HAULAGE LOCOMOTIVES

Baldwin-Westinghouse locomotives and locomotive equipments are manufactured in sizes and capacities suitable for any application involved in mining service. Locomotives in this field are required to operate under a widely varying set of conditions. The locomotives to fill these conditions vary from the small types used for underground haulage to the very largest types—often with cabs or canopy—used for surface haulage in open cuts and quarries, for haulage of ore to mill or smelter



Standard Trolley Type Locomotive

and concentrates from mill to smelter, and general haulage about smelters and metallurgical plants.

They are classified as follows:

(1) Trolley locomotives are generally used for surface work on the heavier hauls and especially where the hauls are long or grades heavy, and in many cases underground.

Standard Storage Battery Type Locomotive

(2) Storage battery locomotives are used for all classes of haulage, both on the surface and underground. Underground, it does away with the trolley wire which is a constant source of danger to men, difficult in many cases to erect and maintain, and increases the fire risk.

(3) Combination locomotives can be operated from either trolley or battery, which feature makes it possible to operate them anywhere that track is laid. They are especially advantageous for work around plants where it is necessary to enter buildings where the presence of trolley wires would be undesirable.

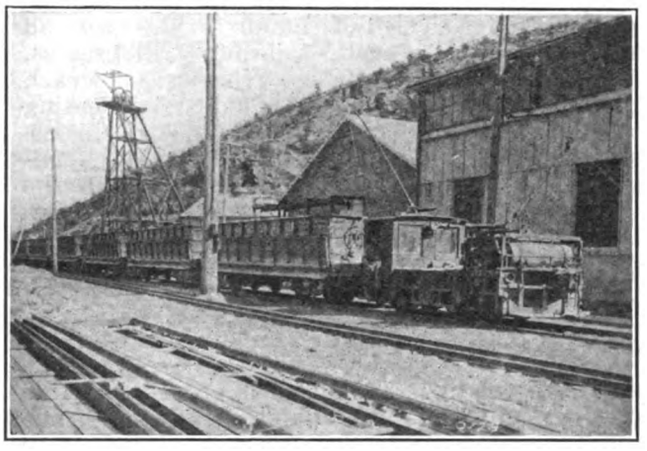
Construction

The side frames of these locomotives are of cast steel open construction. These are known as "Barsteel" frames and have the following distinct advantages:

1. Maximum strength for given weight.
2. Increased ventilation of the electrical equipment.
3. Accessibility for inspection, lubrication and adjustment.
4. Ease with which locomotive can be re-railed in case of derailment.

Wheels may be of cast iron with chilled treads, rolled steel, or cast iron centers with steel tires.

The motors are supported by a cast steel bar, spring suspended from the locomotive frame.



12-Ton Barsteel Locomotive in Operation

The journal boxes are of cast iron with collar cast integral, the lid being constructed to take the end thrust. The journal box can be removed and overhauled longitudinally without removing the pedestal cap or dropping the axle.

The springs are of semi-elliptical type. The use of this type of spring results in a much easier riding locomotive than when they are equipped with ordinary helical springs.

Brakes are of the automatic self-locking type operated by a screw and capable of locking all the wheels. They are easy to manipulate and will meet the most exacting requirements of safety.

The commutating pole motors used practically eliminate sparking, and brush wear is very slight.

Controllers are of the magnetic blowout drum type. Full magnetic controllers are recommended for larger haulage locomotives and are giving excellent results.

Battery Charging Equipment

Westinghouse can supply complete battery-charging outfits for charging either lead or Edison cells for all purposes. In those cases where alternating current only is available, motor-generators are supplied for battery-charging work.

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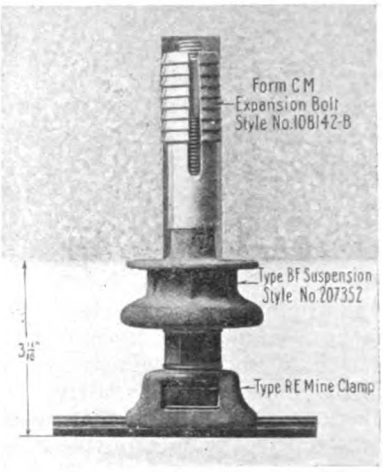
Mine Locomotive Headlights

Locomotive Headlight

Westinghouse Headlights have been designed to withstand the severe conditions under which they are used and yet carry the lamp on a spring suspension which will adequately protect the filament from breakage due to vibration and jars. Space is sufficient to permit use of lamps of from 23 to 94 watt capacity.

Mine Trolley-Line Material

A very complete line of material for supporting the overhead trolley wires in the mine, and on the surface, is manufactured, including expansion bolts, suspensions, clamps, section insulators, cap and cone insulators, wood and composition strain insulators, feed-wire insulators, splicers, frogs, line section switches, etc. Also a complete line of rail bonds, trolley harps and other accessories are carried.



MAINTENANCE AND REPAIRS

Westinghouse engineers have had wide experience with installations of electrical equipment for mine, mill and smelter shops. This equipment consists largely of motor drives for all classes of machines, such as lathes, drill presses, shears, timber framers, saws, grinders, etc., each with control. It includes, also, industrial heating appliances, such as glue pots, and soldering irons. Westinghouse has long made a study of the application of electric motors to small tools, and the large number of these motors used by the manufacturers of electrically driven small tools is a criterion of their success. They are made for either A.C. or D.C.

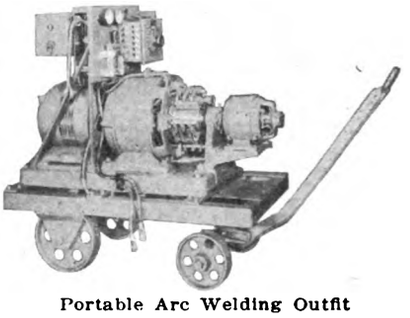
Insulating Compounds and Fabrics

The Westinghouse Company is prepared to furnish for repair work the same line of high-grade insulating compounds and insulated fabrics that go into the manufacture of our own machinery. These are made in great variety, depending on the class of service they are to meet.

Arc-Welding Equipment

Successful application of the arc-welding process is largely dependent on the selection of the proper equipment. The Westinghouse equipment is thoroughly reliable, economical in operation, and at the same time so simple in construction as to require little attention from the operator.

The generator is of the inherent regulating type, so that no external resistance is required in the welding circuit.


Portable Arc Welding Outfit

It is driven by a motor to suit the requirements of the power circuit and is mounted compactly with the motor on a bedplate. For portable service, the motor generator and control panel are mounted on a fabricated steel truck equipped with roller bearing wheels and ample dimensions, so that the equipment can easily be moved.

Westinghouse equipment for arc welding can be supplied in both the single operator and multiple operator type.

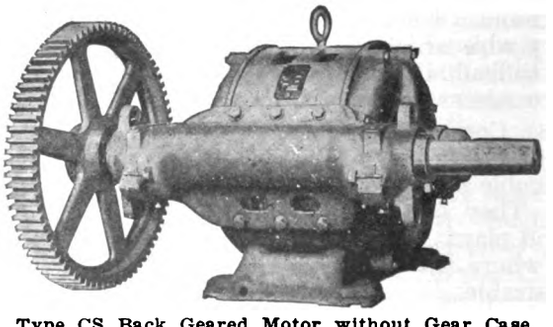
Single operator outfit has a capacity of 175 amperes, and the multiple operator outfits are built in capacities of 300, 500, 750 and 1000 amperes.

ALTERNATING CURRENT MOTORS

For the majority of purposes in mining and metallurgical plants A.C. motors are employed, although there are numerous instances where D.C. motors can be used to good advantage.

Type CS Squirrel Cage Induction Motors

These motors are designed for general service, and are, therefore, suited to many drives in the mines and mills. They are simple in construction, consisting primarily of a set of wire windings, rotating part, or rotor, and two bearings. There is no complication of small parts and no sliding electrical contacts. The bearings are dust-


Type CS Back Geared Motor without Gear Case, showing Countershaft Bracket used on Rolled-Steel Frame Motors.

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proof and automatically oiled. The great mechanical strength of these motors enables them to withstand the severe shocks and stresses of constantly driving machinery. Their efficiency and power factor are high at all loads. These motors can be supplied in all sizes from 2 to 650 H. P.; 2 or 3 phase; 25 and 60 cycles; and for all commercial voltages. They can also be supplied with vertical shafts, back gears, and in other special forms. In metallurgical plants motors often are subject to atmospheres filled with dust, moisture, or chemical fumes. For this class of work a special impregnating treatment is given the windings which render them impervious to moisture, oil, dust and chemical fumes. This type motor is also furnished in the totally enclosed and ventilated type.

Type CW Wound-Rotor Induction Motor

This motor is suitable for constant and variable speed, continuous duty service, where there is required an A.C. motor capable of yielding a strong starting effort, for instance, in driving air compressors, plunger pumps, positive pressure blowers, conveyors that are required to start under a heavy load, hoists, etc. For varying speed service a controller is furnished to obtain continuous operation on any running point from one-half to full speed. These motors can be supplied in any size and for all commercial voltages and frequencies. Either the constant speed or variable speed type can be adapted for belting, gearing, chain - drive or direct connection.

Type CW Motor, Classes 900 and 1000, Showing Cast Frame Construction and Split Brackets.

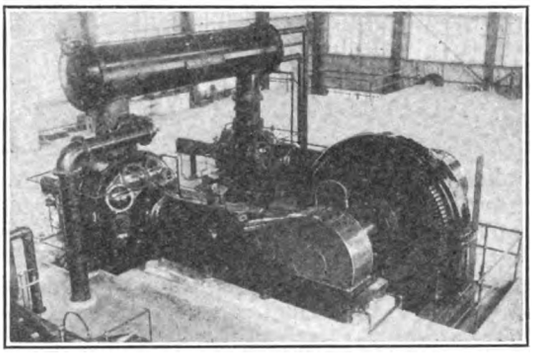
Type CI Wound-Rotor Induction Motor

This motor is designed to meet the same requirements as the type CW motor except that it is intended for intermittent instead of continuous service. It is especially useful for cranes, hoists, elevators, certain types of conveyors which have to be started under heavy load, and, in general, on all machines where the duty consists of successive periods of operation, each requiring a strong starting effort. These motors can be supplied in any required size for all commercial voltages and frequencies.

Synchronous Motors

These form a desirable means of driving pumps, fans, compressors and similar machinery, because in addition to driving the mechanical loads these motors can be used to raise the power factor of the circuits on which they operate. They start as induction motors, auto starters being used for the purpose. After reaching full speed the motor runs on its synchronous windings, field excitation being furnished by a small direct current generator either belted to the motor shaft or mounted on it.

The torque development during starting is approximately 25% of full load and is sufficient to meet light starting conditions, such as usually obtained with centrifugal pumps, reciprocating pumps having by-passes, compressors with unloading devices, etc. Simplicity and ruggedness of construction, economy in operation and maintenance, and moderate first cost are features of these motors.



1200 H. P. Motor Driving Compressors at Anaconda Copper Mining Company, Butte, Mont.

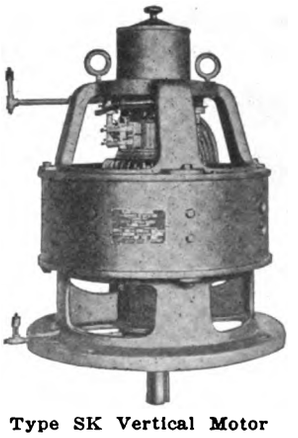
They can be furnished for belted, geared or direct-connected drive, and are made in all commercial sizes, voltages and frequencies.

DIRECT CURRENT MOTORS

There are a number of applications in the mining field where D. C. motors are preferable to A. C. Typical of these is where a wide range of speed adjustment is demanded, as in driving certain types of cranes and hoists. Direct current motors are also preferred in plants where the motor-driven equipment is not extensive and where D. C. has to be generated for other purposes.

Type SK Direct-Current Motor

This motor is suitable for either constant or varying speed and finds extensive applications for all kinds of mine and mill drives. It can be supplied in all sizes from 1½ to 250 H. P. and for 115, 230 and 550 volts. It can also be supplied as a vertical motor and back geared. Like all other Westinghouse motors, it can be had with specially impregnated windings and enclosed frame for use where there is dust, moisture or chemical fumes.



Type SK Vertical Motor

Type K and KG Motors

Westinghouse type K direct - current motors are designed for severe, intermittent, varying speed service, where high-starting torque is required as in the operation of cranes, hoists and similar service.

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Type KG motors are the same in every way as type K except that they are supplied with back-gear parts.

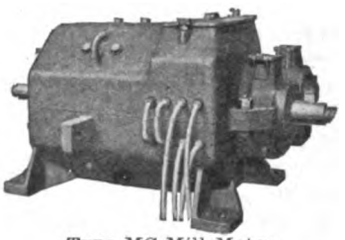
These two types of motors are specially adapted for crane work and are made in totally enclosed types for standard voltages and capacities from 2 to 65 H. P.

Type HK Direct-Current Motors

This is the latest type of motor especially designed for crane service. It is series wound commutating pole type and of enclosed construction with small openings in the lower part of the brackets for ventilation. The most prominent feature of this motor is its compact construction, giving small overall dimensions, light weight, and great mechanical strength. Made from 2 to 25 H. P. for 230 volts.

Type MC and MCO Commutating-Pole Motors

Westinghouse direct-current motors of types MC and MCO are built for operation wherever enclosed motors are required for extremely severe intermittent duty. They will withstand the hardest usage encountered. They have steel frames, massive shafts, very large bearings, fire-proof insulation and other features that insure reliability.



Type MC Mill Motor

The use of commutating poles and careful design insure sparkless commutation under all conditions of load within the capacity of the motor.

Type MC is totally enclosed; type MCO only partially enclosed. Otherwise they are the same. Type MC furnished in sizes from 5½ to 150; MCO from 50 to 300 H. P.; both of 230 volts. Type MCB supplied with back geared parts.

This type of motor is also made for alternating current and is then called Type MA. Furnished in sizes from 5 to 162 H. P. at standard voltages and frequencies.

Small Motors

Westinghouse small motors are available for a variety of power applications requiring from 1/20 to 10 H. P. For alternating current, there are available the types CA, CAH, CSA, AR and ARS. For direct current service, types CD and CDH can be supplied.

MINE AND QUARRY MOTOR APPLICATIONS

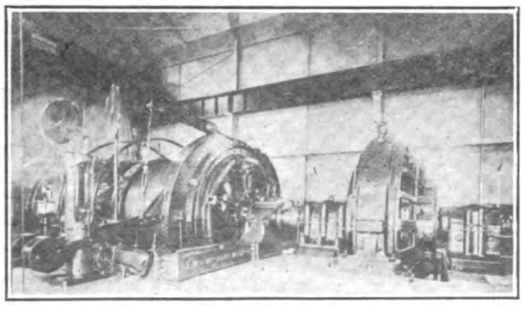
Applications of electrical power to metal mines and quarries are many and constantly increasing. Some of the most important applications to mining and quarrying, other than for haulage, are: Driving air compressors, hoists, pumps, fans, dredges, aerial tramways and cableways.

Electric Mine-Hoist Motors

The use of electric mine hoists is increasing both in mines of large and small capacities. They have a superior speed control, are simpler in operation, have a smaller number of parts, are lighter in weight, more compact and flexible than steam hoists.

The selection of the proper motor and controller is a particular problem for each mine hoist, because the conditions obtaining are different in nearly every case. The rope speed, depth and angle of shaft, duty cycle, output desired, and type and size of hoisting machinery, enter into the choice of design and make it necessary that engineers with a wide and practical knowledge of hoisting work, decide the correct equipment.

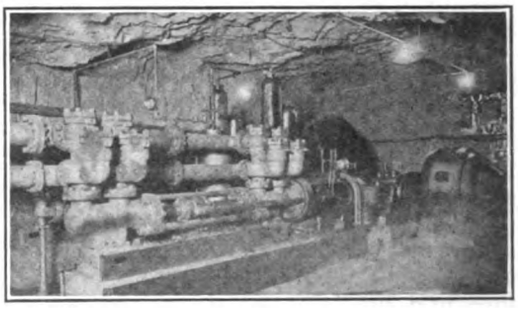
Westinghouse application engineers have had many years of intimate practical experience in the design of electric motors and their application to hoists of all sizes and types for every combination of conditions and are, therefore, qualified to recommend the equipment necessary for successful and dependable operation of mine hoists.



2000 H. P. Hoisting Equipment at North Butte Mining Company, Butte, Mont.

Mine Ventilation Motors

Metal mines are quite commonly ventilated by blower fans in small units placed near the working faces convenient to the power source. Motors may be for either direct or alternating current. They must be strong and rugged to withstand rough handling and to operate with a minimum of attention on temporary foundations in a humid and usually warm atmosphere. The CS and SK types have been found well suited for this work.



Driving Prescott Pump Underground

Mine Pump Motors

Mine pumping places very heavy demands upon motors. The wet and humid conditions under which they work, oftentimes with a minimum of attention, require a rugged moisture-proof construction. The Westinghouse engineers have met this problem with a line of their standard types, both A.C. and D.C., specially protected as to windings with an enclosed self-ventilated frame. Can be furnished for belt, chain, gear or direct-connected drives.

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Dredge and Shovel Motors

The application of electricity to dredges has become almost universal because of its flexibility, economy and reduction of fire risk. Electric shovels are a comparative new field, but have shown great savings in power and have speeded up production greatly.

Motors for this class of service must be rugged, capable of carrying temporary overloads, and operate with their foundations under excessive vibration, oftentimes in damp surroundings. Economy of space is a very important item in these motors.

Aerial Tramways and Cableways

Reduction in power consumption and flexibility obtained, as well as the great advantages of automatic or semi-automatic control are responsible for a rapidly increasing use of motors in this work. Consult Westinghouse engineers concerning the great savings from use of motors in this field.

Mill Motor Applications

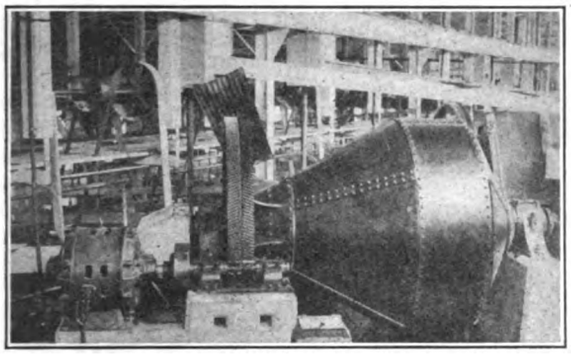
Motors in this field must give continuous operation even under adverse conditions, such as the grit-laden air of the dry crushing plant and the humid fume-laden atmosphere of leaching plants. Some of the applications of motors to concentrating mills are in driving; Crushers and Grinders; Conveyors and Elevators; Concentrating Devices, such as Jigs and Tables; Screens; Mechanical Classifiers and Settling Tanks; Pumps and Flotation Machines.

Crushers and grinders usually require heavy duty motors with very high starting torque, especially with ball and tube mills.

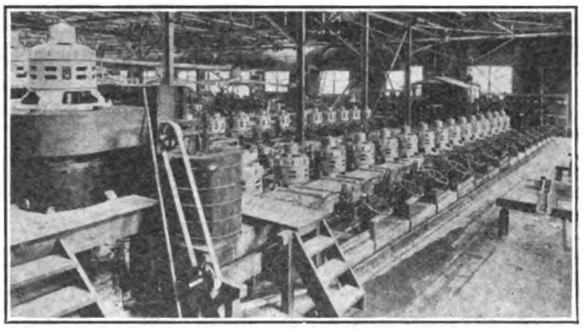
Electric drives have revolutionized conveyor and elevator drives, and have made possible the modern mill with its extensive ore handling system.

Vertical motors have been specially designed for this service in connection with drives for mechanical flotation machines and centrifugal pumps.

Motors are furnished in all standard votages and capacities, D.C. and A.C., for all types of mill drives.



Driving Hardinge Mill



Driving Janney Flotation Machines

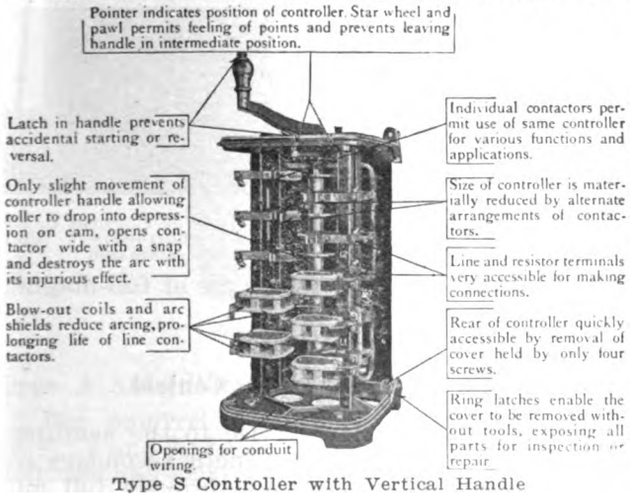
Smelter and Refinery Motors

The application of motors to driving roasters, dryers, conveyors, casting machines, blowers and cranes, and for tilting converters, ladles, etc., has been handled successfully by the company since the application of electricity to this field. The chief problems are those of dust, heat and fumes, and these have been successfully solved by means of special motor frames and windings to resist them.

CONTROL

Type S Drum Controllers

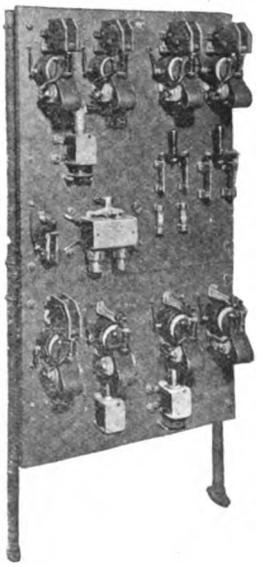
Control for shunt, series and compound wound direct current motors, by adjusting resistance in series and parallel with the motor armature. They are applicable to such severe applications as cranes, hoists, dredges and ore bridges. Maximum ratings, 35, 75 and 125 H. P. at 115, 230 and 550 volts respectively. These controllers are noted for their low maintenance, long life of contacts and general accessibility.



Type S Controller with Vertical Handle

Type C Magnetic-Contactor Controllers

These controllers meet the severe operating conditions encountered in crane, hoist and general mill service. Made in forms AA, BB, CC, DD and EE, which provides reversing, with or without speed control, and dynamic braking. Suitable for series and



Type C Form BB Magnetic-Contactor-Controller

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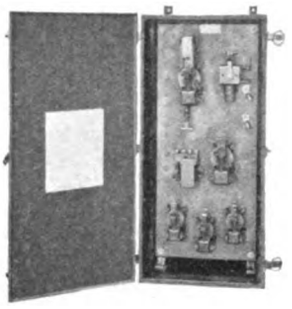
compound wound D.C. motors. They give low-voltage and inverse-time element overload protection.

Type C Automatic Starters

Suitable for constant and adjustable speed D.C. motors. Made in different forms to provide for reversing, non-reversing, dynamic braking or speed control by shunt field as service may require. They are controlled by either push button, float switch, pressure gauge or other type of master switch and are completely automatic in operation. Made in sizes from 1½ to 200 H. P. for 115, 230 and 550 volts.



Type C Form E Automatic Starter

Type D Motor Starting Rheostats

Type D starting rheostats are used for starting shunt, compound and series wound direct current motors. These starters are characterized by strong compact construction. They are self-contained, consisting of a face plate with renewable segments, low voltage release mechanism and self-contained resistance.

Type D Motor Starting Rheostat

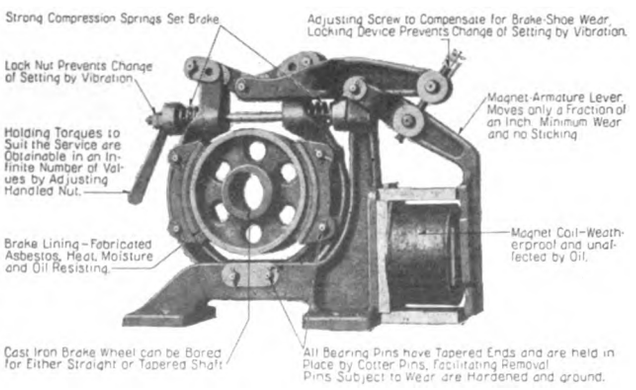
Type DM Motor Starting Rheostats

For use in mines and other places where the apparatus is exposed to moisture and acid fumes. They are practically the same in construction as type D except that they are made impervious to moisture and fumes.

Made from ¼ to 105 H. P. sizes for 110, 220 and 550 volts.

Types A and B Magnet-Operated Brakes

They are used with motors applied to crane, hoist and miscellaneous drives. They will bring motor to a stop quickly without undue strain on the mechanism and also can be used to hold the motor load. Applicable to any motor within their rating.

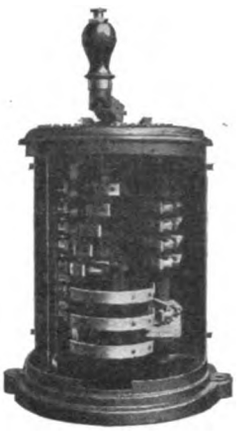


Type B Magnet-Operated Brake

The brake parts are of simple and rugged construction, and their design as a whole makes them easy to install, operate and maintain.

Type A is for alternating current motors from 5 to 200 H. P., voltages of 220, 440, 550, and 2200, and all commercial frequencies.

Type B is for direct current motors from 5 to 400 H. P., and 115, 230 and 550 volts.



Type FA Reversing Controller with Cover Removed

Type FA Drum Controller

Used with A.C. wound rotor motors for starting, stopping and varying the speed. They are simple in construction and reliable in operation. Reversing and non-reversing. For two or three phase, and voltages to 2200 and below; capacities to 200 H. P.

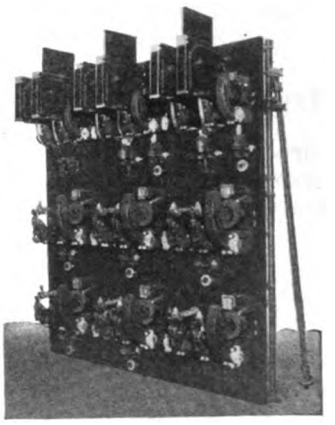
Type RF Control Panel

Type RF Control Panels

Are used for starting and controlling the speed of wound rotor induction motors. They consist of a primary circuit breaker and drum secondary controller mechanically interlocked to prevent improper starting. Primary voltages up to 2200, and capacities to 650 H. P.—two and three phase.

Type F, Form D, Semi-Magnetic Contactor Control

This form of controller consists of primary magnetic reversing contactors operated in conjunction with a type FA drum controller and necessary grid resistor.



2200 Volt Type F, Form D, Full-Magnetic Controller—7 Points Acceleration

These controllers are for 3 phase, wound rotor induction motors, 50 to 450 H. P. and standard voltages. They provide safe and accurate starting, stopping, reversing and speed control of motors driving hoists, cranes and dredges, where the use of full-magnetic controllers is unnecessary.

Type F, Form D, Full-Magnetic Control

Intended for similar service to the semi-magnetic type, but it employs magnetic secondary contactors instead of a drum and provide full auto-

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matic acceleration. It is used for such service as mine hoists and cranes, and generally for larger installations and heavier duty than the semi-magnetic type. For 3 phase; 60 to 1000 H. P. and standard voltages.

Automatic Liquid Slip Regulators

They are used in connection with an A.C.-D.C. flywheel motor generator and D.C. hoist motor for large and heavy duty mine hoists. The Ward-Leonard system of control is used for the hoist motor to facilitate rapid reversal and accurate speed control. The slip regulator controls the speed of the motor generator and utilizes the flywheel to eliminate the otherwise high power peaks on the supply system, which is highly desirable.

D.C. Hoist Control—Ward-Leonard System

This system revises and controls the speed of the D.C. hoist motor by varying the voltage furnished to its terminals by the generator. The generator voltage is varied by changing its field strength. The revising of the motor is obtained by reversing the generator field. Full magnetic control is used and operation is obtained from a small master switch. This system permits rapid and accurate control, eliminates the large losses in armature or secondary resistance found in other systems of control when running at reduced speed.

Starting Switch Complete with Overload and Low Voltage Protection.

Quick-Make and Quick-Break Starting Switches, Types 815 and 816.

For squirrel cage induction motors, 25 H. P. and below, 2 and 3-phase, 25, 40, 50 and 60 cycles and 110, 220, 440 and 550 volts. They connect the motor directly to the line; provide overload and low voltage protection; may be operated by hand or shipper rod.

Have the following advantages: protect operator from shocks and burns; protect both man and equipment against unexpected or accidental starting of motor; protect motor against burnouts without the use of fuses; cannot be held closed on overload; foolproof; reduce shutdowns; long life under severe operating conditions; easy to install.

Type A Auto-Starter

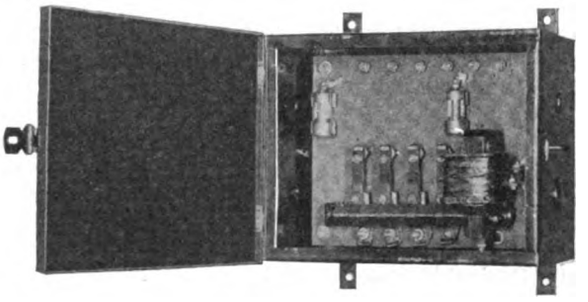
Type A Auto-Starters

For squirrel cage induction motors; 5 to 200 H. P.; 2 and 3-phase; 25, 40, 50 and 60 cycles; 220, 440, 550 and 2200 volts.

Type A auto-starters consist of an auto-transformer unit together with the switching mechanism, low voltage and overload relays all mounted in a dustproof case, arranged for open or conduit wiring. A compact, self-contained unit easy to handle and install. Ask for leaflet 1610-C.

Type F Automatic Starter for Alternating Current Squirrel Cage Motors

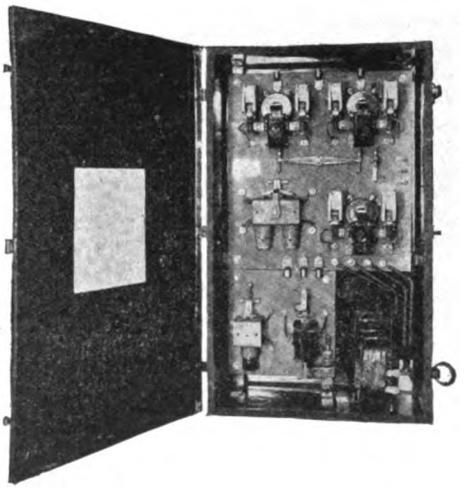
Westinghouse type F line voltage automatic starters connect the motor directly to the line, and combine the advantages of push button, remote control with safety and convenience to the operator and full protection to the motor itself.



Type F Starter for Motors 5 H. P. and Below Line Voltage Type

The outstanding features are: remote control, automatic operation, complete enclosure, low voltage protection, overload protection, single-phase protection, compactness and knockouts for conduit windings.

Maximum horse power, 25; 2 and 3-phase; 110, 220, 440 and 550 volts; 25 to 60 cycles. See leaflets 1667 and 1668.



Type F Starter for 50 H. P., 440 Volts Auto-Transformer Type

Type F automatic starters employing transformers for reducing the starting voltage applied to motors of 5 to 400 H. P. are described in leaflet 1666.

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Products

Controllers, Manual and Automatic—For motors driving hoists, fans, pumps, conveyors, crushers and all other mining machinery.

Electric Brakes—For hoists, conveyors, cranes, etc.

Magnetic Separator Pulleys.

Magnetic Clutches.

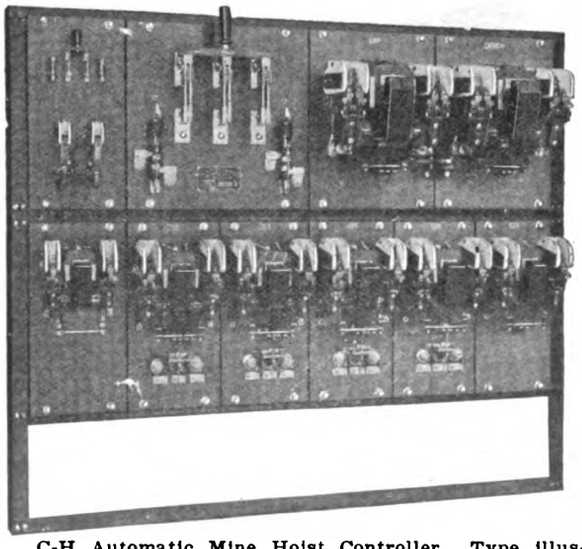
Electric Space Heaters.

Electric Soldering Irons.

For complete information send to nearest office for C-H Mine Publication 836.

C-H Controllers for Mine Motors

C-H Motor Controllers of the plain hand starting type were used on some of the first motors used in mines. The present line of C-H Controllers includes practically every type, both manual and automatic, that is ever used in mine work. C-H Mine Hoist Controllers are designed to develop the maximum capacity and safety of the hoist. C-H Drum Controllers used on small hoists are built of metal throughout; no wood is used. They are capable of



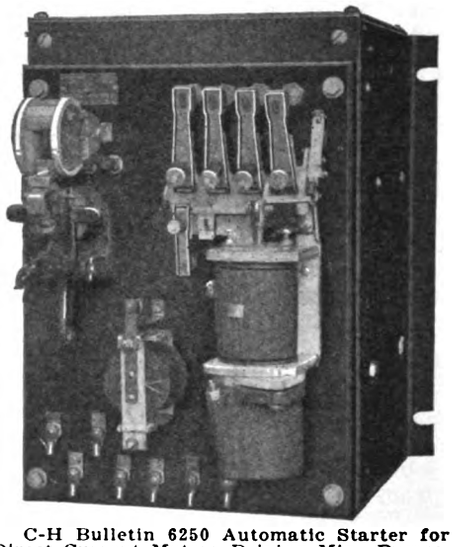
C-H Automatic Mine Hoist Controller. Type illustrated as for use with Slip Ring Induction Motor.

standing up under extremely hard service. C-H Automatic Controllers insure quick acceleration of the hoist. They are designed on the same lines as controllers used in steel mills where the service required is exceptionally severe. For very large hoists, C-H Liquid Rheostats may be used.

C-H Controllers are used on mechanical loaders, both on the big shovel type and on the small loaders used underground.

C-H Controllers Used Underground

C-H Controllers for installation underground where excessive moisture may be present, are carefully protected against the deteriorating effects of moisture and dampness. Operating coils are impregnated with a moisture-proof compound. The



C-H Bulletin 6250 Automatic Starter for Direct Current Motors Driving Mine Pumps, Fans, Etc.

panels, after assembly, are sprayed with a moisture-resisting compound to prevent surface leakage. Iron to iron bearings are eliminated and exposed iron parts are suitably painted or zinc plated. Phosphor bronze springs are used wherever possible.

For mines where the voltage regulation is poor, all coils are designed for operating over a wide range of voltage. C-H Bulletin 6250, illustrated above, is provided with a voltage relay arranged to guard the motor against injury during heavy voltage fluctuations. This controller, like other automatic mine controllers, provides for the continuous operation of the mine pump, fan or other mine machine as long as there is appreciable voltage on the line. This is, in many cases, a very distinct advantage and entirely eliminates the

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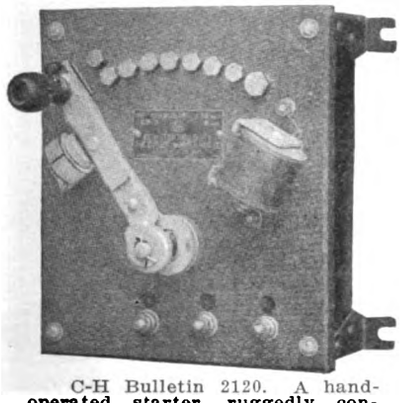
necessity of keeping a man on the watch to start up pumps, etc., after a voltage failure, as is necessary with ordinary hand starters. Automatic controllers like Bulletin 6250 also provide for remote control of the equipment from one or more convenient points.

C-H Automatic Sub-Station Controllers

C-H Automatic Sub-Station Controllers are solving the problem of the small mine sub-station that supplies direct current for mine locomotives, small cutting tools, drills, etc. This control equipment provides for the complete control and protection of a sub-station motor-generator set from the mine power house or from any convenient point. It is entirely unnecessary to keep a man in attendance at the sub-station. The only attention which a C-H Automatic Sub-Station Controller requires is regular trips for oiling and inspection.



C-H Bulletin 2120. A hand-operated starter, ruggedly constructed, suited to the starting of the miscellaneous motors used for various purposes in and about mines.

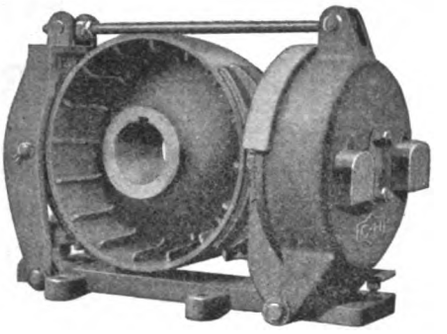
C-H Auxiliary Control Apparatus

C-H Auxiliary Apparatus for use with controllers includes all types of safety switches and relays, master switches, float switches, remote control push button switches—practically everything used in connection with the control of motors.

C-H Bulletin 9141. A sturdily built starter for squirrel cage motors.

C-H Electric Brakes

C-H Electric Brakes are being used with entire satisfaction for all sorts of mine work. Type M Shoe Brakes for direct current service are so designed that the action between the magnet and the brake shoes is direct. This eliminates all intermediate toggles, bell cranks, levers, and cuts down the wear, lost motion and friction to an absolute minimum. The magnet stroke is very short—not over one-eighth of an inch—and insures very quick application and release—no dragging of the brake



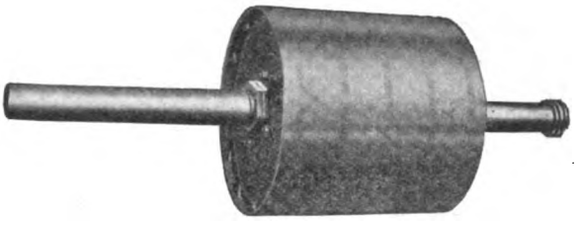
C-H Electric Brake—Type M.

shoes as the motor gets under way. The entire design of Type M Brakes is unusually simple. The rugged steel structure requires a minimum of maintenance expense.

Type RS Shoe Brakes for alternating current service are operated by a rotating magnet which combines maximum safety with a minimum amount of wear and upkeep expense. A smooth, steady application of brake pressure is secured by the special C-H method of connecting the rotating magnet to the brake mechanism. There is no need for a dashpot, which is liable to stick or get out of adjustment.

C-H Magnetic Separator Pulleys

C-H Magnetic Separator Pulleys remove tramp iron from ore of many kinds—protect costly crush-

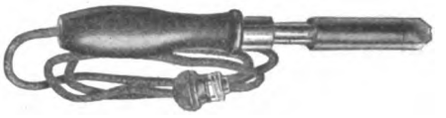


C-H Magnetic Separator Pulley. For protecting crushers and grinders from tramp iron.

ing, grinding and stamping machinery from excessive wear and breakdowns. Such protection is well worth while.

Magnetic Clutches

C-H Magnetic Clutches are used in mine work principally in connection with synchronous motor-driven equipment such as mine fans, pump, mill lines. By using C-H Magnetic Clutches, these motors may be used for comparatively heavy work, the inherent low starting torque of the motor being overcome by these clutches. C-H Magnetic Clutches are well adapted for high speed drives, as they are not affected by centrifugal force. They take up very little room and do not transmit strains along either the driven or driving shafts, as do mechanical clutches.



C-H Electric Soldering Iron. A handy repair tool.

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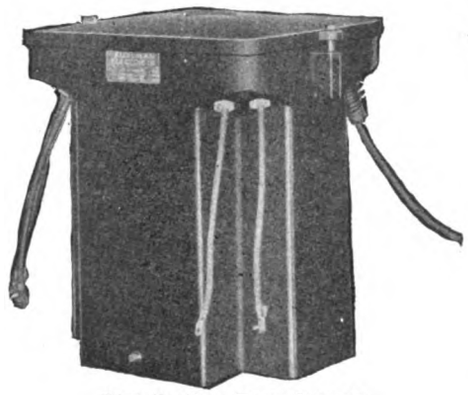
KUHLMAN ELECTRIC COMPANY

BAY CITY, MICHIGAN

TRANSFORMERS

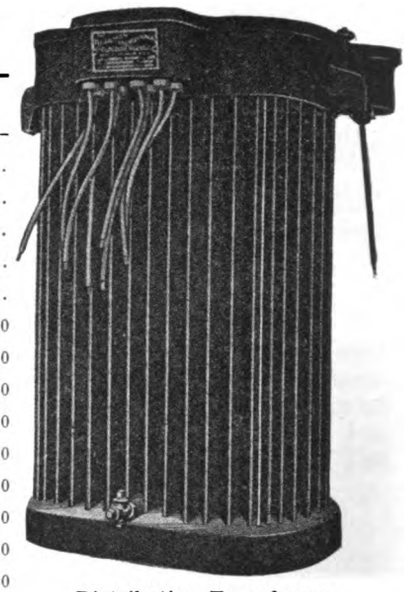
Standard Sizes and Voltages



Distribution Transformer, 1½ to 15 Kva.

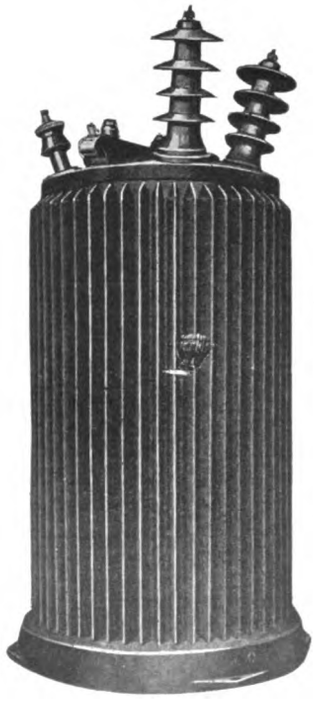
DISTRIBUTION TRANSFORMERS

Kva	Primary Voltage						
1½	2300	4600	6900	.....	.....	.....	.....
2½	....	....	....	11000	13800	.....	.....
3	2300	4600	6900	.....	.....	.....	.....
5	2300	4600	6900	11000	13800	23000	.....
7½	2300	4600	6900	.....	.....	.....	.....
10	2300	4600	6900	11000	13800	23000	33000
15	2300	4600	6900	11000	13800	23000	33000
25	2300	4600	6900	11000	13800	23000	33000
37½	2300	4600	6900	11000	13800	23000	33000
50	2300	4600	6900	11000	13800	23000	33000
75	2300	4600	6900	11000	13800	23000	33000
100	2300	4600	6900	11000	13800	23000	33000
150	2300	4600	6900	11000	13800	23000	33000
200	2300	4600	6900	11000	13800	23000	33000



Distribution Transformer, 25 Kva. to 200 Kva.

Secondary voltages 115/230 or 230/460. No fuse boxes furnished for transformers larger than 50 Kva. or for primary voltages above 2300. No hanger irons furnished for transformers larger than 50 Kva., 60 cycles, or 25 Kva., 25 cycles, or for voltages above 13800. Terminals for voltages above 13800 are brought out through the lid.



Single Phase Station Type.

POWER TRANSFORMERS

Kva	Primary Voltage						
250	2300	4600	6600	11000	13200	22000	33000
333	2300	4600	6600	11000	13200	22000	33000
400	2300	4600	6600	11000	13200	22000	33000
500	2300	4600	6600	11000	13200	22000	33000
667	....	....	6600	11000	13200	22000	33000
883	....	....	6600	11000	13200	22000	33000
1000	....	....	6600	11000	13200	22000	33000

Secondary voltages of 115/230 3-wire, 230/460 to 600 are standard for sizes up to 500 Kva. inclusive.

Secondary voltages above 600 volts are standard for all sizes.

All power transformers have 4-2½% full capacity taps in high voltage winding.

WIRE OR WRITE FOR PRICES. YOUR INQUIRIES WILL RECEIVE IMMEDIATE ATTENTION

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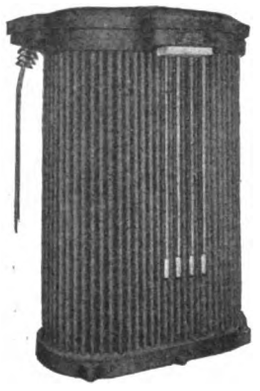
Transformers

"SERVICE" Transformers for use on 2300 V 60 cycle and having secondaries 115-230 V are regarded as STANDARD and are carried in stock in large quantities from which immediate shipments can be made. Stock sizes include 1, 2, 3, 5, 7½, 10, 15, 25, 37½ and 50 KVA. All such transformers are furnished complete with hangers, oil, primary cut-outs, and SEVEN 1¼% TAPS are furnished in the primary windings of all 2300 volt transformers that the secondary can be increased to 253 volts. Special transformers with voltages as high as 275 volts can also be furnished that the proper voltage can be maintained on motors used in connection with coal mining machinery.

Outdoor type for voltages above 16000 and capacities up to 75 KVA.



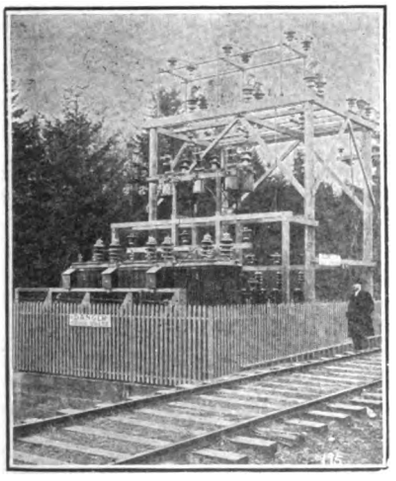
In or outdoor type for voltages as high as 16000 and capacities up to 100 KVA.

"SERVICE" Transformers are furnished for all practical service, for both single and three phase and for any frequency or voltage.

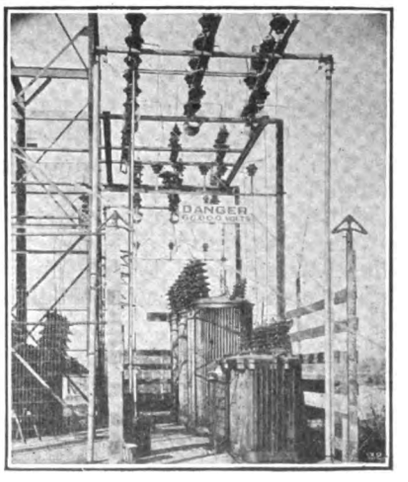
You will find MOLONEY Transformers unexcelled and MOLONEY SERVICE unequalled.

"Power" Transformers for light and power are furnished for all conditions of commercial frequencies and voltages and in sizes up to 5000 KVA single or three phase. A large stock of material and unequalled shop facilities enable us to offer the best SERVICE and exceptional DELIVERIES.

For either 2 or 3 phase in sizes above 100 KVA and in all voltages up to 66000.



A 1500 KVA installation of heavy duty 55000 volt transformers.



Typical outdoor mining installation of 66000 volt transformers.

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Transformers for Every Service

The Packard Electric Company has been manufacturing transformers for over thirty years. Thousands of transformers are telling our story in the mute language of efficient service in all parts of the world.

Just as the character of a man is indicated by the company he keeps, so, we believe, the service rendered by the product of any company can be accurately judged by the standing of the Concerns who consistently use that product. With this thought in mind we have prepared an attractive bulletin illustrating some typical installations of Packard transformers and will be glad to send a copy upon request.

Just ask for Bulletin No. 210.

The selection of the proper transformers for your specific conditions of service, means to you above anything else, DOLLARS and SATISFACTION. There is one inevitable transformer law and that is "When a transformer goes down—the overhead goes up". Your transformers spell either liability or reliability, depending first as to whether they are geared to your particular load, and next on their design and the material and workmanship that go into them. The fundamental transformer equation reads as follows: $E = \frac{4.44 \times B \times A \times F \times T}{10^8}$ where E = EMF; B = Flux Density in Core; A = Area of Core; F = Frequency; T = Number of Turns. This equation contains three unknown quantities B, A and T. It will be readily appreciated that real engineering ability and experience are necessary in proportioning these three unknown quantities so as to build transformers which will exactly meet your particular requirements.

The idea that a "transformer is a transformer" is a moth-eaten fallacy. Transformers are as distinctly different from each other as automobiles or motors and those for your plant should be adapted to your specific load requirements. If you buy a transformer so designed, constructed of the best material and built by skilled artisans, you are going to eliminate annoying shut-downs with their resultant increase in overheads.

Packard Transformers are—

Correctly Designed—Of adequate capacity—Built by high class skilled workmen.

Amply insulated—Properly ventilated—Constructed of the best materials.

Ruggedly braced—Filled with highest quality transformer oil.

Packard Transformers are built in accordance with the established standards of the Electric Power Club and the American Institute of Electrical Engineers. When properly installed they are bound to be a source of satisfaction to you and of pride to us.

Transformer for Every Service, Built to Render But One Kind of Service, "THE BEST"

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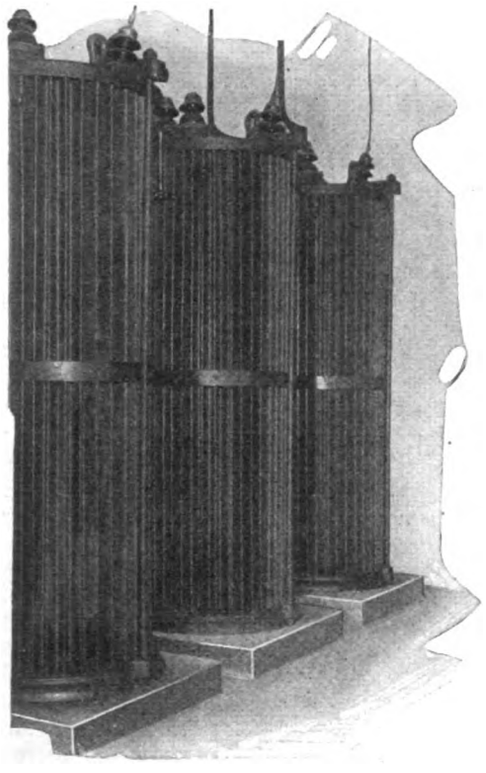
The Electric Power Club is an association of manufacturers of electric power apparatus and control equipment, organized for the standardization, improved production and increased distribution of electrical machinery and apparatus.



The work of the Electric Power Club has meant the saving of millions of dollars to the buyers of electrical apparatus. One of the outstanding benefits of their work is to be found in the standard method of tests which they have established for transformers. This makes it possible for the buyer to make accurate comparisons of the operating characteristics of different makes of transformers and to select the one best suited to his particular requirements; viz.: Electric Power Club standards require that guarantees as to losses and efficiencies shall be based upon a reference temperature of 75° C and that load losses shall be measured by wattmeter when adequate voltage is applied to primary winding to produce rated current in the secondary winding, the latter being short circuited.

CAUTION—Do not compare transformer load losses based on the obsolete practice (I^2R values at 25° C) with those based on present standard practice (wattmeter measurements at 75° C). Such a comparison would be unfair to both the buyer and seller and no reputable manufacturers will submit figures based on I^2R values at 25° C.

In the design of Packard transformers, due consideration has been given to the variable characteristics, each of which is, to a certain extent, dependent upon the other. We have, therefore, given the losses a scientific balance which results in the greatest economy and service to the purchaser. We court a fair comparison and are only too glad to place Packard Transformers in competitive test with any other transformer on the market.

We have secured a supply of Bulletins published by the Electric Power Club covering the "latest transformer standards" and will be glad to send you one of these bulletins upon request.

For the purpose of effecting economies in the manufacture and sale of transformers a definite range of sizes has been adopted as constituting a standard line. For your convenience we list below a tabulation of these sizes in the 2300 volt and 6600 volt line of distribution transformers, together with mechanical data. Further data on these transformers and complete information on power transformers will be furnished promptly upon request.

PACKARD TYPE A HIGH EFFICIENCY DISTRIBUTION TRANSFORMERS

Oil-Immersed Self-Cooled Outdoor Type for Single Phase 60 Cycle Service—Temperature Rise 55°C.

High Voltage	Low Voltage
2200	110/220
2300	115/220
2400	120/240

KV-A	Outlined Dimensions (Inches)		Gallons Oil Per Trans.	Net Weight (Pounds)	
	Height Over Cover	Projected Floor Area		Trans. Only	Oil
1½	15	15x11	1¼	117	10
3	17	17x12	1¾	145	14
5	22	19x14	3¼	240	26
7	28	22x15	5½	340	44
10	28	22x15	5	380	40
15	31	26x17	7	490	56
25	32	28x22	19	475	152
37½	38	28x22	28	600	224
50	40	34x26	34	1150	272
75	52	40x28	72	1450	576
100	70	40x28	105	1800	1290
150	82	45x31	190	2200	1635
200	100	45x31	240	2500	1895

PACKARD TYPE A HIGH EFFICIENCY DISTRIBUTION TRANSFORMERS

Oil-Immersed Self-Cooled Single Phase 60 Cycles

Temperature Rise 55°C.

High Voltage	Low Voltage
6600/11430 "Y"	110/220

KV-A	Outlined Dimensions (inches)			Gal. Oil	Approx. Shpg. Weight, Lbs.	
	Height Over Cover	Floor Area	Height Over Bushings		Trans. Only	Oil
1½	17	17x12	..	3	140	24
3	28	22x15	..	5	232	40
5	28	22x15	..	8	300	64
7½	31	26x17	..	9	375	72
10	33	27x19	..	13	575	104
15	33	27x19	..	40	650	320
25	33	28x21	..	20	600	160
37½	40	34x26	..	52	1100	416
50	46	40x28	55	65	1350	520
75	63	40x28	73	100	1500	800
100	69	45x31	79	160	2000	1280
150	81	45x31	91	190	2400	1520
200	88	54x36	98	310	3000	2480

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Pittsburgh Transformer Company

PITTSBURGH, PENNSYLVANIA

Largest Manufacturers of Transformers Exclusively in the United States

District Offices

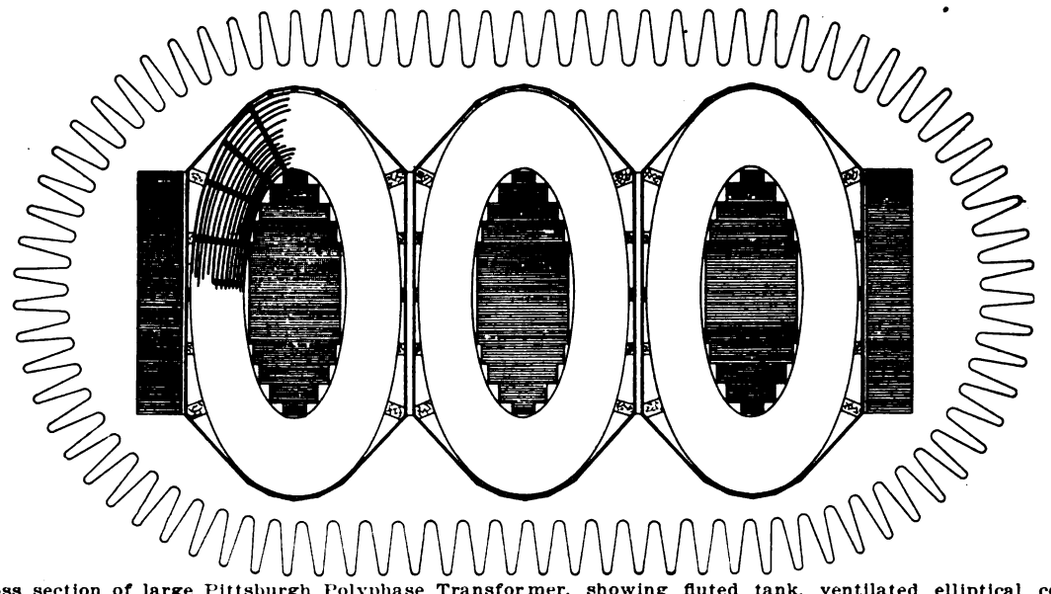
NEW YORK.....30 Church Street
CHICAGO.....724 Harris Trust Building
BUFFALO.....601 Electric Building

Distributors

PHILADELPIA—Rumsey Electric Company
BOSTON—Wetmore-Savage Company
DETROIT—F. R. Jennings Company
AKRON—Verne W. Shear & Company
CLEVELAND—Verne W. Shear & Company
PITTSBURGH—Iron City Electric Company
BIRMINGHAM—General Machinery Company
CINCINNATI—Piper Engineering Company
SEATTLE—Eicher & Bratt
SAN FRANCISCO—Coast Equipment Company
LOS ANGELES—Coast Equipment Company
ST. LOUIS—W. L. Rose Equipment Company
ATLANTA—Southern Electric Supply Company
CHARLESTON—Engineering Service Company
GREENVILLE—Southern Textile Machinery Co.
NEW ORLEANS—Interstate Electric Company
KANSAS CITY—J. F. Schaefer & Company
ST. PAUL—Savage & Winter Company
INDIANAPOLIS—R. M. Cass
SALT LAKE CITY—F. W. Wilson
DES MOINES—F. H. Boyer
DENVER—Intermountain Sales Company
LINCOLN—Enterprise Electric Company
CHICAGO—Federal Electric Company

Pittsburgh Polyphase Transformers

A distinctly "Pittsburgh" development for three phase operation. The only transformer, we believe, manufactured today that can be operated Open Delta three phase, the result of the more efficient, symmetrical Pittsburgh Polyphase design, which also accomplishes higher efficiency.



Cross section of large Pittsburgh Polyphase Transformer, showing fluted tank, ventilated elliptical coils and core closely conforming to the elliptical aperture.

Compared with three single phase transformers of equal capacity, this new Pittsburgh Polyphase Transformer has the following advantages:

Less Weight.
Less Space Occupied.
Lower Core Loss.
Lower First Cost.
Lower Maintenance Charges.
Lower Transportation Charges.
Lower Cost for Supporting Platforms and Poles.
Lower Installation Cost.
Higher Efficiency.
Will Operate Open Delta.
All Steel.

The Pittsburgh Polyphase Transformer is not a mere improvement,—it is a fundamental change in design, resulting in a more efficient transformer.

In addition to this high efficiency, the Pittsburgh Polyphase Transformer has none of the disadvantages, when operating three phase, that the old three phase transformer exhibited. For instance, in the Pittsburgh Polyphase Transformer, if one coil is damaged, the remaining two coils may operate open delta. No other three phase transformer on the American market today will operate open delta, we believe.

Another characteristic, demonstrating the fundamental difference in the Pittsburgh Polyphase Transformer, is that it will operate full capacity single phase.

As a further indication of the flexibility and adaptability of the new Pittsburgh Polyphase Transformer, two of the phase windings may be operated open delta three phase for motor load, and the remaining winding operated single phase for lighting load, if desired.

The improved efficiency and better operating characteristics in the Pittsburgh Polyphase Transformer are secured in the basic design, involving the mutual relation of the materials, more than from the actual quantity of materials used.

Pittsburgh Single Phase Transformers

Like the Polyphase Transformers, Pittsburgh Single Phase Power and Distributing Transformers employ the double magnetic circuit core with vertical coil surrounding the central leg, which has proven so successful.

All Pittsburgh Transformers have the elliptical coil construction,—a fundamental invention and development of the Pittsburgh Transformer Company. The elliptical coil permits the legs of the core to be deep and narrow, which is best for magnetic and inductive efficiency. This design results

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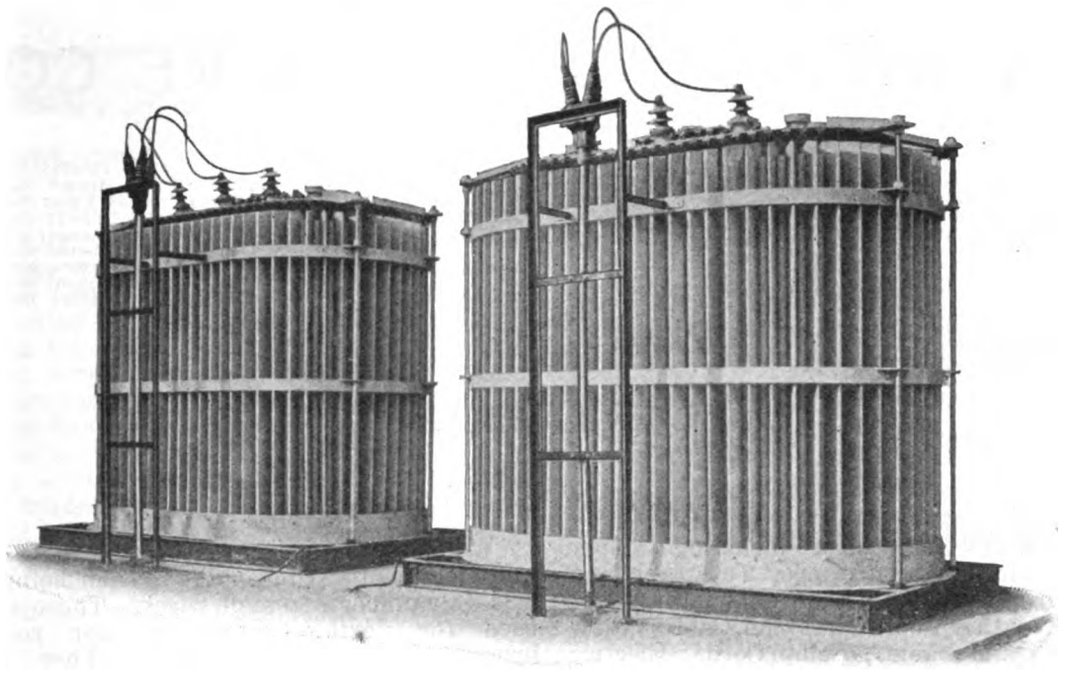


An installation of two 3000 Kva Pittsburgh Polyphase Transformers operated by Edison Electric Illuminating Company, Boston, Mass.

in low exciting current, and low exciting current is of the utmost importance to prevent surges when switching transformers on and off the lines, as well as keeping up a high power factor.

At the same time, this design permits ample cooling channels to be formed in the coils. These vertical cooling channels establish a vigorous circulation of the cooling oil. Furthermore, the coil rigidity, due to this elliptical construction, not only contributes to the mechanical life of the transformer, but aids in a large measure in preventing disintegration or break-down of surrounding insulation.

Pittsburgh Features

All Pittsburgh Transformers are wound with standard copper. No special copper of any kind is employed. Thus in five, ten or twenty years, should accidents occur to the transformers, the copper wire can be secured from stock and no delay occur in repairing.

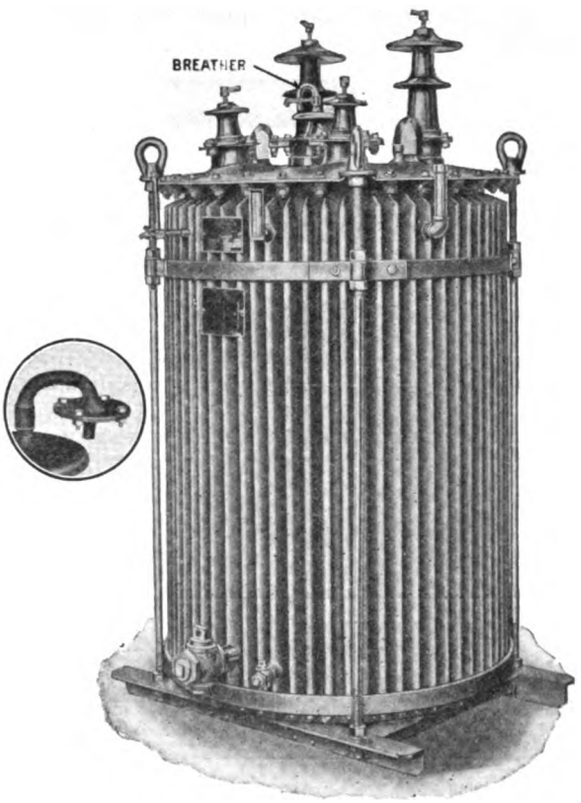
Tanks are made wholly of Copper Alloy Steel, in our own factory, and every detail receives our personal supervision. No cast iron is used in any Pittsburgh Tanks to hold oil. In the larger tanks, we have heavy Copper Alloy Steel bottoms welded in—not cast iron with vertical corrugations of sheet steel. Porous cast iron will not hold hot transformer oil without leaking and cast iron is also much heavier. For these reasons we have abandoned the use of cast iron entirely as a container for oil.

All Pittsburgh Power Transformers are so constructed that they may be shipped full of oil, and all the customer has to do on receipt of the transformers is to connect them to the line. No hoisting of oil barrels in the air and draining into the tank. Transformers can be installed more cheaply, and several days quicker and no drums to return.

Pittsburgh Transformer Breather

All Pittsburgh Power Transformers, Single and Polyphase, are air-tight and equipped with the Pittsburgh Breather. This device prevents the entrance of moisture into the transformer, and removes dust and dirt from the air entering the transformer.

Extensive and long-continued tests have proven the value and efficiency of the Pittsburgh Breather, and we recommend and urge that this additional protection be given your transformers. The Pittsburgh Breather may be installed on transformers of any make, and as the cost is negligible for the safety provided, we believe this additional factor of safety is well worth its cost.



Pittsburgh Power Transformer with Breather mounted on top of Safety Valve

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AMERICAN STEEL & WIRE CO.

SALES OFFICES

CHICAGO.....208 So. La Salle Street
NEW YORK.....30 Church Street
WORCESTER.....94 Grove Street
BOSTON.....185 Franklin Street
PHILADELPHIA.....Widener Building
PITTSBURGH.....Frick Building
BUFFALO.....337 Washington Street
DETROIT.....Foot of First Street
CINCINNATI.....Union Trust Building
CLEVELAND.....Western Reserve Building
BALTIMORE.....32 So. Charles Street
WILKES-BARRE, PA.....Miners Bank Building
ST. LOUIS—Liberty Central Trust Company Bldg.
KANSAS CITY.....417 Grand Avenue
ST. PAUL-MINNEAPOLIS.Pioneer Bldg., St. Paul
OKLAHOMA CITY...1st National Bank Building
BIRMINGHAM, ALA.....Brown-Marx Building
DENVER.....1st National Bank Building
SALT LAKE CITY.....Walker Bank Building

Export Representative: U. S. Steel Products Co., New York
Pacific Coast Representative: U. S. Steel Products Company
San Francisco Los Angeles Portland Seattle

ELECTRICAL WIRES

Products

Electrical Wires and Cables, including Copper Trolley Wire; Hard Drawn Copper Telegraph and Telephone Wire; Magnet Wire; Annunciator Wire; Office Wire; Weatherproof Wires and Cables; Slow Burning Wires and Cables; Lamp Cords; Electric Heater Cord; Rubber Covered Wire for Interior Wiring; Feeder Cables; Switchboard Cables, Rubber Covered; Fireproof Cables; Duplex and Concentric Cables; Fixture Wire; High Voltage Cables; Lead Encased Cables for Lighting and Power; Galvanized Telephone and Telegraph Wire; Rail Bonds.

Everything in the Wire and Cable line.

Copper Trolley Wire

Trolley wire is made generally of hard drawn copper in three shapes, Round, Grooved and Figure 8. Though seldom called upon to make trolley wire larger than 4/0 or smaller than 1/0 American Wire Gauge, we are prepared to make other sizes.

We can furnish any size copper wire cut to special lengths.

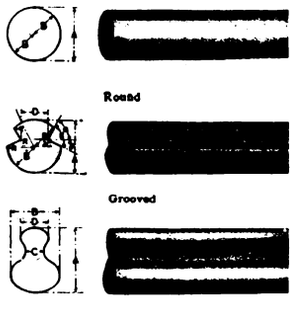


Figure 8

DIMENSIONS OF HARD DRAWN COPPER TROLLEY WIRE

Section of Trolley Wire	American Wire Gauge (B. & S.)	Sectional Area in Cir. Mils	A	B	C	D
Round	0	105,600	.325	.1625	....	....
	00	133,200	.365	.1825	....	....
	000	168,100	.410	.205	....	....
	0000	211,600	.460	.230	....	....
Grooved American Standard"	00	133,200	.392	.196	.03125	.20
	000	168,100	.430	.215	.04688	.22
	0000	211,600	.482	.241	.0625	.25
Figure 8	00	133,200	.480	.352	.108	.196
	000	168,100	.540	.400	.130	.222
	0000	211,600	.600	.450	.150	.250

Extra Flexible Cables

We manufacture bare copper cables having a high degree of flexibility due to their being made of a large number of small wires. These cables are used for flexible connectors, for commutator brushes, and similar purposes. They are made both concentric and rope lay.

Hemp Core Cables

In order to reduce the skin effect in conductors carrying heavy alternating currents of high frequency, it is customary to use a specially constructed cable having a hemp center. This style of cable is also required in many long distance transmission lines in order to increase the diameter enough to prevent corona effects due to very high potentials.

We are prepared to manufacture this style of cable to any specifications.

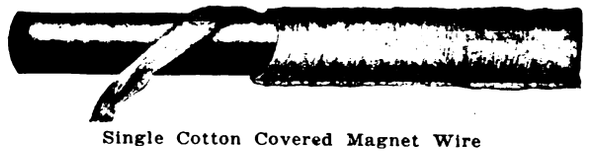
Special Transmission Strand

This is a combination of High Strength Steel Wire and Hard Drawn Copper Wire, twisted into a concentric strand of 7, 19, 37 or more wires, the copper wires being on the outside.

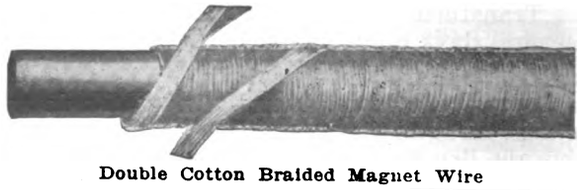
The essential feature of this combination is the high tensile strength it affords. It is especially useful in cases where it is necessary to stretch the transmission lines over long spans.

Magnet Wires

All copper wire drawn for magnet purposes is thoroughly annealed by processes which insure uniform and extreme softness, highest conductivity and ease of handling. Before the insulation is applied, the wire is thoroughly inspected for size and uniformity of dimensions and to see that it is free from scale and other surface imperfections.



Single Cotton Covered Magnet Wire



Double Cotton Braided Magnet Wire

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Round Asbestos and Single Cotton Covered Magnet Wire

All magnet wire is insulated in special machines by skilled operators. We are not only prepared to produce large quantities of the ordinary commercial sizes of cotton covered magnet wire, but are also in position to and do furnish large amounts of fine sizes for special work, both silk and cotton. All magnet wire is not only inspected for knots, skips, smoothness and unevenness of insulation during manufacture, but is given a final inspection and test for continuity before packing.

Magnet wire is furnished covered with single, double or triple cotton or silk, with asbestos and cotton, and with paper. We are also prepared to make special kinds of magnet wire for particular purposes. The covers are wound spirally around the wire, successive layers being wound in opposite directions.

Made in American Wire Gauge (B. & S.) from 0 to 19. Finer sizes made from 20 to 40 gauge.

Annunciator Wire

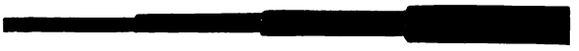
This wire is used for primary battery circuits, for call bells or annunciator wires. Commercially pure, soft copper wire, varying in size from No. 14 American Wire Gauge (B. & S.) to No. 22 is used. This is insulated with two firm winds of cotton applied in opposite directions and saturated with our specially prepared paraffin wax compound. The outside wrap is made of any color or combination of colors, the most common being bright and fast red or blue, with white. This wire is put up on spools weighing about 7 pounds net.

Annunciator Wire

Office Wire

The standard grade consists of a copper conductor varying in size from No. 14 to No. 20 American Wire Gauge, insulated with one wind and one braid of cotton, both of which are applied tight and even. This grade of wire is used extensively for telephone and telegraph inside wiring.

Office Wire



"Black Core" or "Damproof" Office Wire

Weatherproof Wires and Cables

This grade has a moderate degree of insulation and is less expensive than rubber insulated conductors. For outdoor service, our double and triple braid Reliance Weatherproof Wire meets these requirements in every particular, while for inside purposes we offer a superior grade of Slow Burning Wire. We make these wires and cables in strict accordance with the requirements of the National Board of Fire Underwriters, the sizes varying from No. 20 to the largest feeder cables used, American Wire Gauge.

Reliance Weatherproof Insulation

The wires are first covered with two or three closely and evenly woven braids of strong fibrous material, after which they are placed in a hot bath of weatherproof insulating compound, where

Reliance Weatherproof Wire
Solid Copper Wire, Double Braid, Black Finish

Reliance Weatherproof Wire
Solid Copper Wire, Triple Braid, Black Finish

Reliance Weatherproof Cable
Stranded Copper Conductors, Double Braid, Black Finish
All Above Made from 0000 to 18 Gauge Inclusive

Reliance Weatherproof Cable
Stranded Copper Conductors, Triple Braid, Black Finish
All Sizes up to No. 8 Gauge

Reliance Weatherproof Iron Wire, Double Braid
Made in Sizes from 4 to 18 Gauge Inclusive

Reliance Weatherproof Iron Wire, Triple Braid

they remain sufficiently long to completely and thoroughly saturate the fibrous insulation. After thoroughly drying, the wire receives a dressing of mineral wax, after which the surface is burnished and polished, reducing to a minimum trouble from sleet and ice. The superior grade of compounds used in our Reliance Weatherproof insulation for wires and cables imparts a high degree of dielectric strength and overcomes the destructive action of the elements. This insulation is firm, durable and tough and possesses great mechanical strength, which enables it to withstand pressure and mechanical abrasion. The compounds contain no solvents which subsequently evaporate, leaving the compound to dry and fall out, thus destroying the insulation. They will withstand all ordinary climatic conditions.

Reliance Slow Burning Wires and Cables

The insulation of this wire will not carry flame. It is especially useful on the backs of large

Reliance Slow Burning Wire
Solid Conductor, Triple Braid, White Finish

switchboards where wires are brought together, or in a wire tower, where the accumulation of rubber

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or weatherproof insulations would result in an objectionably large mass of highly inflammable materials. This wire is made in strict accordance with all of the requirements of the National Board of Fire Underwriters. Each insulation braid is

Reliance Slow Burning Cable
Stranded Copper Conductor, Triple Braid, White Finish

completely saturated with our white slow burning compound and the outside is thoroughly slicked down and given a hard, smooth, white surface.

Made in all commercial sizes.

Special Weatherproof and Slow Burning Wires

We are prepared to furnish the above for special purposes. The wires may have a single coating of black weatherproof and white slow burning coverings or they may have three coatings, two of slow burning and one of weatherproof, or conversely as specified. Made in accordance with the requirements of the National Board of Fire Underwriters.

We are also prepared to furnish any of these various kinds of weatherproof or slow burning wires twisted into pairs, or formed into cables having any number of conductors, the conductors so formed being encased in one or more finished braids or with tape and braid, as may be specified.

Lamp Cord

Incandescent lamp cord in short lengths is used for exposed wiring in offices, etc., to connect the concealed wiring with drop lights, brackets and portables. Can also be used for any purpose where a short flexible connecting conductor is desirable. The conductor consists of a number of small untinned annealed copper wires, each No. 30 American Wire Gauge, having a diameter of .01 in., twisted into a cable of the required carrying capacity. This conductor is then covered with a tight, close wind of cotton, after which it is insulated with seamless rubber and then covered with an ornamental braid of silk or cotton. Two of these finished conductors are then twisted together, or in some cases they are laid parallel and braided overall with silk or cotton, in each case forming the two branches of a circuit.

Lamp Cord of All Kinds and Sizes

Made in gauges of from 10 to 22 inclusive, American Wire Gauge, and put up in coils of 250 feet. Sizes 16 and 18 are put up in packages containing 1000 and 3000 feet each, as desired.

Americore Rubber Covered Wire

The conductor consists of a uniformly soft annealed commercially pure copper wire. It may be used in the solid form up to size 1/0, or in special cases even up to 4/0, or in the stranded form. All conductors are thoroughly and evenly coated with tin to protect the copper from any injurious effect from the sulphur in the rubber insulation.

Made in all sizes and for all voltages.

Americore Wire, Solid Tinned Copper Conductor

Americore Cable, Stranded Tinned Copper Conductor

Americore Feeder Cable

Americore Rubber Covered Switchboard Cable

Duplex Concentric and Parallel Flexible Cables

Made in American Wire Gauges from 2 to 10 inclusive.

Parallel Flexible Cable

Duplex Concentric Flexible Cable

Duplex Concentric Cable is made in American Wire Gauges from 4 to 8 inclusive.

Amerite Wires for Arc Light and High Voltage Transmission Lines

These rubber covered wires and cables are made to the most exacting specifications, in any size or finish and for all services and voltages. The insulation contains only the highest grade of Para rubber and other necessary preserving ingredients of proper composition and thickness for the service for which the cable is intended.

Solid Conductor, Insulated and Braided

Twin Wires, Insulated and Braided

Conductors can be furnished solid, stranded or extra flexible, as ordered, annealed and heavily tinned.

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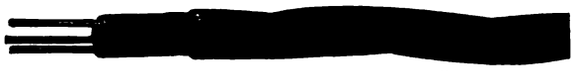
Sub-Station Wire

Made in Single Conductor, Twisted Pair and Triple Conductor, for inside service. Conductors are No. 9 American Wire Gauge, soft drawn tinned copper, insulated to a diameter of 3/32 of an inch over rubber, covered with a single hard glazed cotton braid. Each style has different color of cover for easy identification.

Double Conductor Sub-station Wire



Triple Conductor Sub-station Wire

Rubber Covered Iron Telephone Wire

This is a single conductor, generally of No. 18 or No. 14 American Wire Gauge, the conductor being iron wire galvanized and insulated with code thickness of vulcanized rubber, either single or double braid, weatherproof saturated and wax polished. Can be furnished in twisted pairs.

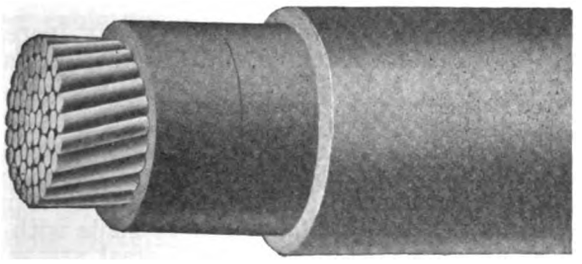
Rubber Covered Iron Telephone Wire

Lead Encased Lighting and Power Cables

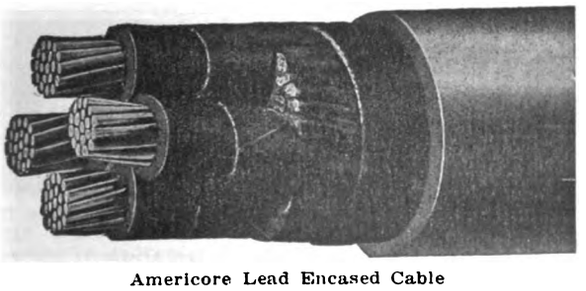
For underground, submarine or aerial service. A heavy rubber cable, lead sheathed, armored or lead encased and armored for all services and voltages and finished in any style. This form of enclosure has proved the most effective for resisting the destructive agencies in mine work.

We also contract for the complete installation of underground or submarine cables, or superintend installations as may be required, having a large and well equipped department for this class of work.

Americore Lead Encased Cable



Americore Lead Encased Cable



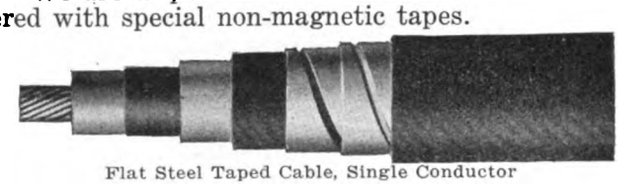
Americore Lead Encased Cable

Flat Steel Taped Cables

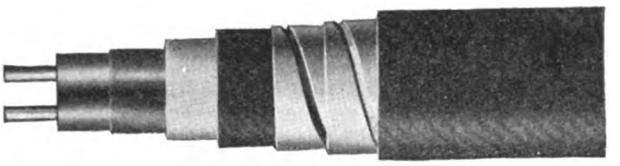
This type of cable is a standard for lighting purposes and in places where installation is difficult or impossible owing to the absence of ducts. It is installed by laying in a trench 15 to 30 inches deep. It is economical and easy to install and really makes a safe and reliable substitute for the more expensive conduit system.

Made with Single, Twin and Three conductors, thoroughly insulated, taped separately, covered with lead over all, then jute, first steel tape, second steel tape, then jute over all.

We are in position to furnish these cables covered with special non-magnetic tapes.



Flat Steel Taped Cable, Single Conductor



Flat Steel Taped Cable, Double Conductor

Extra Galvanized Telephone and Telegraph Wire

There are three standards of galvanized telephone and telegraph wires in commercial use.

"Extra Best Best" (E. B. B.) made by improved continuous process and stands highest in conductivity of any telegraph wire with a weight per mile ohm under 5,000 lbs. Uniform in quality, pure, tough and pliable.

"Best Best" (B. B.) Superior to the E. B. B. in mechanical qualities and equal in galvanizing, but of somewhat lower electrical value. Weight per mile ohm 5,600 to 6,000 lbs. Largely used in telephone service.

"Steel" (or homogeneous metal) more expressly designed for short line telephone service, where a measure of conductivity can be exchanged for high tensile strength in a light wire. Weight per mile ohm 6,500 to 7,000 lbs.

All grades are galvanized to the highest commercial standard.

Made in American Wire Gauges of 4, 6, 8, 10, 11, 12 and 14, but can be supplied in special gauges when required.

American Tinned Steel Armature Binding Wire

Made in American Wire Gauges of from 10 to 26 inclusive, and in four grades.

Grade A—115,000 to 125,000 lbs. tensile strength per sq. in. Used to bind Armatures of small motors and dynamos.

Grade B—200,000 to 220,000 lbs. tensile strength per sq. in. Commercial grade, used for motors and dynamos of ordinary commercial size and speed.

Grade C1 or Grade Special—240,000 to 270,000 lbs. tensile strength per sq. in. Made of high grade rope wire and used where great strength is required.

Grade C2 or Grade C—300,000 to 350,000 lbs. tensile strength per sq. in. Used on motors and dynamos of unusual size and high speed.

Armature Binding Wire is furnished in coils or on spools. Standard coils weigh from 5 to 75 lbs. each. Standard spools weigh 5, 10, 25, 50 and 100 lbs. each.

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HAZARD MFG. COMPANY

WILKES-BARRE, PA

NEW YORK 533 Canal Street | PITTSBURGH First Nat'l Bank Bldg. | CHICAGO 552 W. Adams Street | DENVER 1415 Wazee Street | BIRMINGHAM 1701 First Ave.

INSULATED WIRES AND CABLES

"MADE FOR USERS WHO WANT THE BEST"

Products

Rubber Insulated and Bare Copper Wires and Cables for Light and Power Transmission, Telephone, Telegraph, Signals, Mining Machines and Electric Locomotives.

Rubber Covered Wires and Cables

Manufactured of pure copper wire, drawn true to gauge in our own mills, thoroughly tinned. The Rubber Insulation is compounded of the highest grades of Para rubber and stands up under the most rigid requirements of service. The braids are closely woven and thoroughly saturated with weatherproof compound to make them impervious to water and weather. All Wires before shipping are subjected to test in tank under voltages much higher than those encountered in actual service. HAZARD Wires and Cables bear our guarantee of satisfactory service.

Hazard Spiralweave Cables

For use in locations where especially severe conditions of acid water, moisture or abrasion are encountered. SPIRALWEAVE Cables possess

great longitudinal strength and will stand an extraordinary amount of wear and abrasion. They are especially serviceable for shaft signal work, and inside power lines.

Hazard Spiralweave Cord

A hard service extension cord, for use in connection with portable lights and electric tools of all kinds.

No. 18—Two-Conductor Spiralweave Cord

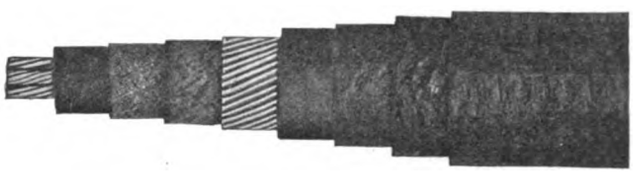
HAZARD SPIRALWEAVE Cord is very flexible and has exceptional tensile strength. The cover is an extra heavy, tough and wear-resisting weave. The heavy multiple cotton cords run parallel to the conductors instead of at an angle and therefore supply strength to withstand the hard pulls which are often encountered.

Bare Copper Wires and Cables

For Telephone and Power Transmission, Bonds, etc.

Mining Machine Cables

HAZARD Mining Machine Cables are made in Twin flat form or Concentric Round form. The braids are heavy and closely woven to protect the



Concentric Mining Machine Cable, Style "A"

rubber insulation, and thoroughly saturated with weatherproofing compound to prevent the injurious action of moisture. For the outer covering we strongly recommend HAZARD Hard Service Braids, described here.

Hazard Hard Service Braids

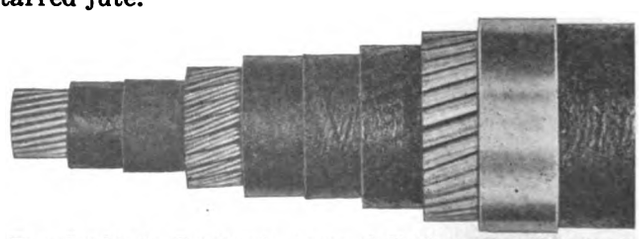
These braids, consisting of hard double twisted seine twine, are designed to minimize the wear on the outer coverings of portable conductors. This

Hazard Hard Service Twin Mining Machine Cable

special hard and tough covering greatly increases the life of Mining Machine and Locomotive Cables at a comparatively slight increase in first cost.

Armored Cables

HAZARD Armored Cables for power transmission down shafts and bore holes are made to meet special requirements. They may be made with protective coverings of rubber, lead, steel armor and tarred jute.



Two Conductor Concentric Armored Shaft or Borehole Cable

(See Page 422 on Hazard Wire Rope.)

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Standard Underground Cable Co.

Factories: St. Louis, Mo.; Oakland, Calif.; Pittsburgh, Pa.; Perth Amboy, N. J.

Branch Sales Offices

BOSTON NEW YORK PHILADELPHIA WASHINGTON PITTSBURGH ATLANTA CHICAGO ST. LOUIS DETROIT KANSAS CITY SAN FRANCISCO LOS ANGELES SALT LAKE CITY SEATTLE

FOR CANADA: Standard Underground Cable Co. of Canada, Ltd., Hamilton, Ont.

STANDARD Electrical Wires, Cables and Cable Accessories

For All Electrical Requirements; Telephone, Telegraph, Signal, Lighting, Power, Etc.

Products

Tubes, Rods, Shapes—Copper, Brass and Bronze. Write for Bulletin 100.

Bare Wire and Cable—Copper, Bronze and Colonial Copper Clad, solid or stranded, for all purposes. Write for C. C. C. Bulletin 202.

Magnet Wire—Round, Flat and Rectangular Shapes; Single, Double or Triple Insulation, Cotton or Asbestos.

Weatherproof and Slowburning Wires and Cables—Double or Triple Braid Insulation. Write for Bulletin 400.

Rubber Insulated Wires and Cables—"Sterling" National Electrical Code standard, "Tip Top" intermediate, 30% Para, and all standard or special specification material, for all classes of service. Write for Bulletin 500.

Mine Cables—All standard types of Mining Cables, Gathering Locomotive Cables, etc. Write for Bulletin 500.

Lead Covered Cables—Rubber, Varnished Cloth or Paper Insulation, for all working voltages and all classes of service.

Armored Cables — "Wearproof," "Basket Weave," Double-Steel-Tape or Wire Armors furnished on any type of cable. Write for Bulletin 680.

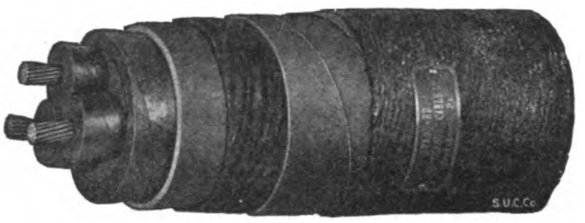
Special Finishes—Weatherproof, Flameproof, Seine Twine, Circular Loom, Asphalted Jute or Special "P" finish (to resist acid mine water) furnished on any type of cable.

Bore Hole Cable—Any type of leaded or non-leaded cable furnished with special wire armor with supporting head, and served at intervals of 25 feet, so designed as to prevent the cable slipping inside the armor. Furnished with Bore Hole Cable Support, D.O.A. and "Mine Shaft" Terminals, complete. Write for Bulletin 700.

Cable Accessories—Terminals: Type D.O.A. for outdoor service and Type D.S. for indoor service. Write for Bulletins 700 and 710.

Junction Boxes add flexibility to power cable distribution systems.

Jointing Materials, including "Ozite" Insulating Compound, Copper Connectors, Insulating Tapes, Jointing Tubes, etc. Suitable cable accessories insure proper protection and facilitate the installation and operation of cables. Write for Bulletin 740.

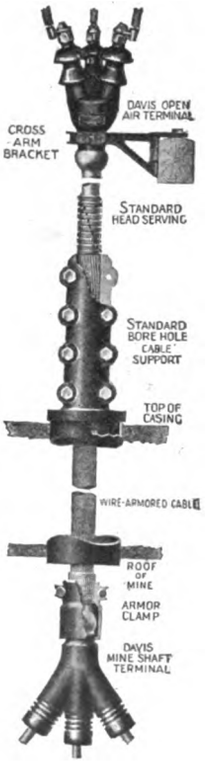


Paper Insulated Double-Steel-Tape-Armored Cable

Gathering Locomotive Cable
Braid may consist of weatherproof jute, hemp or seine twine.

Type DS (Indoor) Cable Terminal

Type DOA (Outdoor) Cable Terminal



Bore Hole Cable Complete with Cable Support and Terminals

Construction Work

Our trained experts are available to install or supervise installation of our cables.

Communicate with our nearest office for further data, prices, etc. Our 40 years' experience are back of our products and at your service.

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BUSSMANN MANUFACTURING CO.

ST. LOUIS

DEALERS AND DISTRIBUTORS IN EVERY PRINCIPAL CITY

Manufacturers of Electric Fuses

BUSS Renewable Fuses, 3 to 60 Amp.

Hands are all you need to renew this fuse. No searching for tools. Full length cap gives such a large gripping surface that anyone can pull the cap up tight without a screwdriver.

Four parts and the renewal link all that have to be handled in renewing this fuse. All parts are readily accessible, which with the reduced number of parts and the simplicity of all parts makes it possible to renew this fuse in least possible time, and renders it impossible to make a mistake in assembling the fuse. The washer is perfectly flat. It can only be assembled **one way—the correct way.** Good contact is always assured.

Cap has six full threads. Impossible to have the threads crossed without it being plainly apparent.

Link cannot twist or turn. On the closed end, this is very evident and on the other end the oblong hole or slot is so placed in washer as to hold link against side of square hole in end ring thus preventing twisting of the link.

Good contact insures long life of renewable fuses. Poor contact is the only and invariable cause of charred fibre tubes. The Buss fuse practically eliminates this loss because of these reasons:

Full length one-piece cap assures 100% contact with fuse block clip.

The firm grip of the fuse clips keeps vibration from loosening the cap which maintains contact pressure on the link. To insure good contact, see that clips grip cap tightly.

Projection in cap gives positive bearing on link. Recess in cap collects all expelled metal thereby preventing sticking of cap and injury to contact surface.

End rings are attached to tube by threads and pins. The pins are driven in from the end, and prevent rotation of the rings.

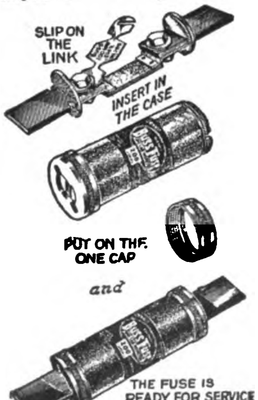
Caps do not overlap the fibre tube. Swelling of the tube will not prevent readily taking off and easily putting back on of caps.

BUSS Renewable Fuses, 65 to 600 Amp.

Three parts and the link are all that have to be handled in renewing this extraordinary fuse. Saves time in renewing. Saves loss of small parts. Least possible number of parts to be handled.

Terminals held together by a terminal support. Saves time in renewing —makes renewal easy. Prevents any possible strain or injury to the link. Terminals are always perfectly aligned. This terminal support is made of fibre. It is so constructed and used, that its durability in every way equals that of the fibre tube.

Closing washers are permanently attached to the terminals. No small parts to lose or misplace. No loose washers to be handled in renewing. Impossible to but partially assemble the fuse.



Knurled Venting Discs insure positive, reliable and controlled escape of gases. Venting is through a positive path (not through cap threads) and prevents excessive and perhaps bursting strain on case. Retains sufficient pressure inside case to quench arc, yet releases enough pressure to avoid any injury to case. Action is uniformly of one kind—the right kind. Positive, reliable and controlled escape of gases adds measurably to life of case.

Inner rings prevent distortion of fibre tube. Rings are always sure to be tight whether fibre shrinks or swells.

Only one removable cap. Only one cap to handle in renewing, other cap is permanently connected to the case. Fuse cannot be wrongly closed.

All parts extremely simple. Insures long life and unlimited renewals. No tricky or annoying adjustments to be made in assembling. Fuse will never be thrown out by an inexperienced or irritated workman. All easily broken parts are eliminated.

Renewal Links

Identical in size and interchangeable with all Standard makes of renewable fuses.

	Amperes	Length Over All Inches	Diam. of Tube Inches	Weight Per 100 Fuses Lbs.	Std. Pkg.	Price Complete Fuse	Price Renewal Link
250 Volt	3 to 30.	2	½	6	100	$ 0.50	$0.03
	35 to 60.	3	¾	16	100	1.00	.05
	65 to 100.	5⅞	1	48	50	2.00	.10
	110 to 200.	7⅛	1½	116	25	4.00	.15
	225 to 400.	8⅝	2	235	25	7.50	.30
	450 to 600.	10⅜	2½	356	10	11.00	.60
600 Volt	3 to 30.	5	¾	19	100	1.10	.05
	35 to 60.	5½	1	36	100	1.25	.06
	65 to 100.	7⅞	1¼	74	50	3.00	.10
	110 to 200.	9⅝	1¾	167	25	5.00	.15
	225 to 400.	11⅝	2½	462	25	11.00	.30
	450 to 600.	13⅜	3	540	10	16.00	.60

All sizes approved and labeled "UND. LAB. INSPECTED."

Buss Cartridge Non-Renewable Fuses

"Buss" Non-Renewable Fuses carry this label: UND. LAB. INSPECTED.

Ferrule Contact Type, 1 to 60 Amperes

Knife Blade Type, 65 to 1000 Amperes

	Amperes	Length Over All Inches	Diam. of Tube Inches	Weight Per 100	Std. Pkg.	List Price
250 Volt	1 to 30.......	2	½	4.5 lbs.	100	$ 0.20
	35 to 60.......	3	¾	11.0 lbs.	100	0.30
	65 to 100.......	5⅞	1	31.0 lbs.	50	0.90
	110 to 200.......	7⅛	1⅛	80.0 lbs.	25	2.00
	225 to 400.......	8⅝	2	160.0 lbs.	25	3.60
	450 to 600.......	10⅜	2½	275.0 lbs.	10	5.50
	650 to 800.......	11½	3	430.0 lbs.	10	12.00
	850 to 1000.......	12⅝	3½	540.0 lbs.	10	15.00
600 Volt	1 to 30.......	5	¾	15.0 lbs.	100	0.40
	35 to 60.......	5½	1	25.0 lbs.	100	0.60
	65 to 100.......	7⅞	1¼	55.0 lbs.	50	1.50
	110 to 200.......	9⅝	1¾	120.0 lbs.	25	2.50
	225 to 400.......	11⅝	2½	290.0 lbs.	25	5.50
	450 to 600.......	13⅜	3	430.0 lbs.	10	8.00
	650 to 800.......	14½	3½	540.0 lbs.	10	15.00
	850 to 1000.......	15⅝	4	725.0 lbs.	10	18.00

"Buss" Open Link Fuses

Guaranteed for accuracy and reliability.

All copper terminals.

Amperes	Term No.	Slot Inches	Width Inches	Std. Pkg.	To 1⅛ in.	1⅝ to 3½ in.	3⅝ to 5 in.	5⅛ to 8 in.
1 to 30..	1	3/16	⅜	100	$0.03	$0.04	$0.05	$0.06
35 to 60..	3	3/16	9/16	100	0.04	0.05	0.06	0.07
65 to 100..	5	¼	11/16	100	0.05	0.06	0.08	0.10
110 to 200..	7	⅜	¾	50	.....	0.10	0.15	0.20
225 to 400..	16	7/16	1 1/32	50	.....	0.22	0.22	0.30
450 to 600..	10	½	1⅜	50	.....	0.40	0.40	0.60
650 to 1000..	28	⅝	2 1/16	10	.....	0.75	0.75	1.00

"Buss" Fuse Wire and Strip

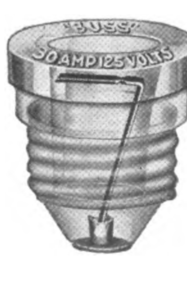
½ to 3 ampere fuse wire spool contains ½ lb.

4 to 50 ampere fuse wire spool contains 1 lb.

60 to 200 ampere fuse wire spool contains 5 lb.

Fuse strip is packed in 5 lb. cans —all in one piece.

"Buss" Mica Top Plug Fuses



Guaranteed Clear Window—10-in-a-carton. Approved by Underwriters' Laboratories.

Amperes	Catalog No.	List Price
3	803	
6	806	
10	810	
12	812	$0.07
15	815	
20	820	
25	825	
30	830	

Packed 10 in a carton, 200 in standard package. Shipping weight 75 lbs. per M.

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CHICAGO FUSE MFG. COMPANY

Laflin and 15th Streets
CHICAGO
73 Barclay St., NEW YORK CITY

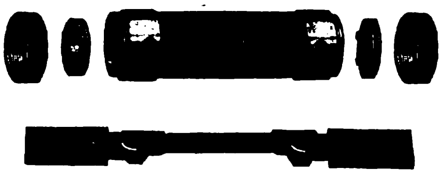
"UNION" Renewable Cartridge Fuses

Approved by the National Board of Fire Underwriters in all sizes of N. E. C. standard dimensions for both 250 and 600 volt service.

If the current flows smoothly and evenly, and the fuses used are of the proper rating and capacity for the requirements of the installation, "UNION" Enclosed Cartridge Fuses of **non-renewable** type will give the best protection at the lowest cost.

If the circuit is subject to overloads or any fluctuation in the flow of current whereby frequent replacements are necessary, "UNION" **Renewable** Fuses are the best investment possible, giving absolute protection to the circuit at the greatest saving in cost of maintenance. If renewable fuses are economical in any given condition, "UNION" **Renewable** Fuses offer the utmost in this direction, being heavier, stronger, and more simply constructed, and at the same time the best designed mechanically and electrically.

The heavy, strong construction insures their lasting longer than any other fuses of this type, thereby giving a greater return for the investment.



Type E "Union" Renewable Fuse

The simplicity of construction insures an easier and quicker renewal of the fuse when blown, saving time, and "time is money."

Type E "Union" Non-Renewable Fuse

SOME OF THE ADVANTAGES OF "UNION" RENEWABLE FUSES

Type B (Ferrule)

1. The heavy brass parts are securely attached to the outside of tubing.
2. All parts are so rugged that the fuse will withstand renewing indefinitely.
3. It is quickly and easily renewed. When the cap is unscrewed the washer supporting the end of the renewal link is exposed and if it does not drop off of its own accord, it is very easily removed.
4. No tools of any kind are required to make the renewal.
5. The heavy metal parts insure cool running. Official tests on both the 30 amp. and 60 amp. sizes show that their temperatures run much below the limits specified by the Underwriters' Laboratories' Standard.
6. Links are supplied with one end bent to save time and insure accurate insertion.

Type E (Knife Blade)

1. The metal ferrules are securely riveted and screwed onto the outside of tubing.
2. In renewing, this connection to the tubing is not disturbed, all changes being made between long-wearing metal surfaces.
3. The number of parts is small and they are easily assembled. Result: Saving of time and expense in renewing.
4. The flexibility of the knife-blade fastenings allows the blades readily to adjust themselves in the mounting clips, and so make good contact.
5. No tools except an ordinary screwdriver or monkey-wrench are needed for making renewals.
6. Safety valves at each end of larger sizes where needed permit gases to escape quickly when fuse blows.

250 VOLTS

Amperes	Length Over All	Diameter Tube	Standard Package	List Price Fuse	List Price Renewal
3- 30*	2	½	100	$0.50	$0.03
31- 60*	3	¾	100	1.00	.05
61- 100*	5⅞	1	50	2.00	.10
101- 200*	7⅛	1½	25	4.00	.15
201- 400*	8⅝	2	25	7.50	.30
401- 600*	10⅜	2½	10	11.00	.60
601- 800	11½	3	10	24.00	.80
801-1000	12⅝	3½	10	30.00	1.00

600 VOLTS

Amperes	Length Over All	Diameter Tube	Standard Package	List Price Fuse	List Price Renewal
3- 30*	5	¾	100	$1.10	$0.05
31- 60*	5½	1	100	1.25	.06
61- 100*	7⅞	1¼	50	3.00	.10
101- 200*	9⅝	1¾	25	5.00	.15
201- 400*	11⅝	2½	25	11.00	.30
401- 600*	13⅜	3	10	16.00	.60
601- 800	14½	3½	10	30.00	.80
801-1000	15⅝	4	10	36.00	1.00

Note: Above dimensions are in inches and are same as for N. E. C. Std. Non-Renewable Fuses.
*Manufactured under Underwriters' Lab., Inc., Label Service.

"UNION" ENCLOSED FUSES (Non-Renewable Type)
Approved January 29, 1907
Manufactured under Underwriters' Lab., Inc., Label Service

250 VOLTS

Amperes	Length Over All	Diameter Tube	Standard Package	List Price Fuse	Refilling Price
3- 30	2	½	100	$0.20	.....
31- 60	3	¾	100	.30	.....
61- 100	5⅞	1	50	.90	$0.60
101- 200	7⅛	1½	25	2.00	.90
201- 400	8⅝	2	25	3.60	1.50
401- 600	10⅜	2½	10	5.50	2.00
601- 800*	11½	3	10	12.00	4.00
801-1000*	12⅝	3½	10	15.00	5.00

600 VOLTS

Amperes	Length Over All	Diameter Tube	Standard Package	List Price Fuse	Refilling Price
3- 30	5	¾	100	$0.40	.....
31- 60	5½	1	100	.60	.....
61- 100	7⅞	1¼	50	1.50	$0.80
101- 200	9⅝	1¾	25	2.50	1.20
201- 400	11⅝	2½	25	5.50	2.00
401- 600	13⅜	3	10	8.00	3.00
601- 800*	14½	3½	10	15.00	5.00
801-1000*	15⅝	4	10	18.00	6.00

*Underwriters' Lab., Inc., do not issue approval on any type of fuse above 600 amps.

"Union" Fuses have 30 years of manufacturing reputation to maintain and we can not afford to make them otherwise than perfect.

Both of these types are for sale by all leading electrical supply jobbers and dealers.

We are the oldest and largest manufacturers of Switch Boxes, Cut-Outs, Fuse Plugs, Automobile Fuses, Renewable and Non-Renewable Enclosed Fuses.

FULL DESCRIPTIVE BOOKLET SENT ON REQUEST

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ECONOMY FUSE & MFG. CO.

Greenview Ave. at Diversey Parkway, CHICAGO, U. S. A.

Atlanta, Ga. Baltimore, Md. Boston, Mass. Buffalo, N. Y. Cincinnati, Ohio Cleveland, Ohio Detroit, Mich. Denver, Colo. Kansas City, Mo. Los Angeles, Cal. Milwaukee, Wis. Minneapolis, Minn. New York, N. Y. Philadelphia, Pa. Pittsburgh, Pa. St. Louis, Mo. San Francisco, Cal. Seattle, Wash.

ECONOMY FUSE & MFG. CO. OF CANADA, LTD., MONTREAL, CANADA

Complete Stocks Carried By All Leading Electrical Jobbers and Dealers

Products

Clearsite Non-Renewable Plug Fuses; Economy "Approved" Renewable Cartridge and Plug Fuses; "Drop Out" Renewal Links; "Arkless" Non-Renewable Indicating Fuses.

Also manufacturers of Moulded Insulation and S.&C. High Potential Fuses (in Canada).

CLEARSITE NON-RENEWABLE PLUG FUSES

"CLEAR INDICATION ALWAYS."

Clearsite fuses are the only non-renewable plug fuses using the famous Economy "Drop Out" Link. This link, with amperage stamped upon it, is mounted with the operative section of the element directly under a window of unusual design. Clear-

Clearsite Non-Renewable Plug Fuse
APPROVED BY UNDERWRITERS' LABORATORIES, Inc.

site fuses never fail to indicate. When blown on an overload a gap at the operative section is clearly visible; when blown on short circuit the window is blackened and vision of link is made impossible. Clearsite fuses, in capacities of from 3 to 30 amp. are sold in cartons of 500 and of 50, and in retail packages of 4 for 25c.

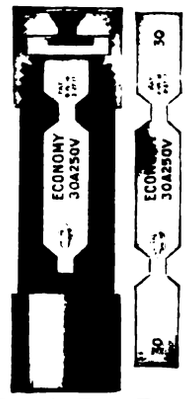
IMPROVED ECONOMY RENEWABLE FUSE—

Economy fuses are made in three general types (ferrule, plug and knife blade), with a full line of capacity ranges for all commercial voltages. This was the first line of fuses approved in all capacities by Underwriters' Laboratories, Inc., established and maintained by the National Board of Fire Underwriters, employing an inexpensive bare link for restoring a blown fuse to its original efficiency.

The fusible elements are of the "Drop Out" renewal link type, accurately rated and of definite design. Every part of an Economy fuse is built on the "safety first" principle, which means that the design is right from an electrical standpoint, and that material entering into the construction of the completed fuse is the best that money can buy.

Sectional View, Knife-blade Type

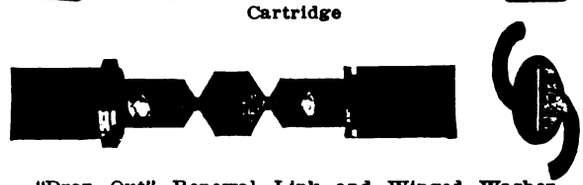
Study the renewable link feature. See the two narrow bridges of metal holding the "Drop Out" features in place. In operations on short circuits, these two bridges fuse. The entire fuse metal does not volatilize, only the two narrow bridges. This very greatly decreases the danger factor due to the tremendous pressure generated when an entire strip of fusible metal is instantly converted into gases. No powdered filler to deteriorate or solidify. Only the fuse metal is destroyed; the fuse itself is ready for years of service. See the winged washer which makes it simple and easy for anyone to replace the "Drop Out" renewal link in a few minutes.



Ferrule Type Fuse and "Drop Out" Renewal Link

ECONOMY FUSE SAVINGS—There is 80% of fuse maintenance cost saved yearly, as compared to the cost of securing adequate protection by the use of non-renewable "one-time" fuses.

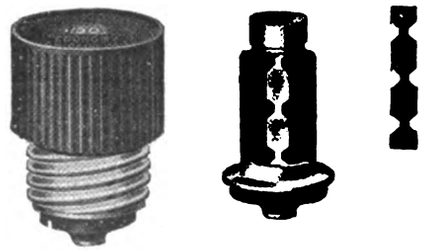
Cartridge



"Drop Out" Renewal Link and Winged Washer
Economy Knife Blade Fuse Disassembled

"DROP-OUT" RENEWAL LINK—It is the heart of an Economy Fuse. It instantly restores a blown Economy Fuse to its original efficiency at the absolute minimum of cost.

A stock of "drop-out" links, always on hand, represents a small investment.



Plug Type Fuse—Sectional View—"Drop Out" Renewal Link

ECONOMY RENEWABLE PLUG FUSES—Use of the "Drop Out" renewal link in this plug type fuse results in similar operation and saving as in the Economy cartridge type fuses. No tools are required to replace the blown link and restore the plug to its original efficiency

"ARKLESS" NON-RENEWABLE INDICATING FUSES—We are also sole manufacturers of "Arkless," the non-renewable fuse with the "100% guaranteed indicator." For use on circuits not subject to frequent overloads.

Samples

Any capacities sent on request, provided they are to be used for comparison and tests. Ask for Catalogue 10 when ordering samples.

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FEDERAL ELECTRIC COMPANY

8700 South State Street, CHICAGO

91 New Montgomery Street, San Francisco 130 W. 42nd Street, New York

Branches in All Large Cities

Products

Federal National Renewable Fuse; Federal National Multiphase Renewable Fuse; Federal 3-30 Renewable Fuse Plug.

Federal National Renewable Fuse

The principle of a powder packed renewable element in a renewable fuse has been recognized by the highest engineers as the only design that can give absolute yet economical protection. The Federal National Renewable Fuse, the Federal National Multiphase Fuse and the Federal 3-30 Fuse Plug all have this same principle, which eliminates the possibility of improper loading or overloading, confines the fierce heat of the arc when the fuse blows, preventing damage to terminals and heating of contact points, causing premature blowing. This feature eliminates the necessity of overloading as is done where a cheap naked element is used, in order to prevent the fuse from blowing prematurely, and as a consequence eliminates the danger of the fuse not blowing when it should.

Federal National Renewable Fuse

The Federal National Powder Packed Renewable Cartridge Fuse for D.C. and Single Phase circuits operates successfully, stands the strain of a motor when started and blows when it should. The same applies to the Federal National Multiphase Fuse and the Federal 3-30 Fuse Plug. In addition to the positive protection feature (which after all is the main reason you buy fuses) this powder packed element permits ease of renewing a blown element. With the aid of a screw driver, the blown element can be removed in a jiffy. No complicated parts. The operator knows because of a metal tell-tale indication that he is reloading the fuse properly. No possible confusion.

The Federal National Powder Packed Renewable Cartridge, ferrule type, consists of three parts only—fibre holder, powder packed renewable element, and metal cap.

Federal National Fuses are made in all capacities from 3 to 600 amperes, both 250 and 600 volts.

Federal National Multiphase Renewable Fuse

The Federal National Multiphase Time Limit Powder Packed Renewable Fuse is the only absolute protection for multiphase motors and circuits. It eliminates two of the greatest causes of lost protection, which are constant interruptions by premature operation of the protecting devices and the failure of the protecting device to operate at the critical moment.

Most motor installations today are of the multiphase (polyphase) type and the burning out of such motors is due to overloading the protecting device and to motors running as single phase motors when one fuse blows and there is no way in which the circuit breaker or controlling device can be operated.

The National Multiphase Fuse protects the motors and circuits on starting and running load,

Federal National Multiphase Renewable Fuse

and also eliminates any possibility of multiphase motors running as single phase. It embodies the same features as the National Fuse, such as powder packed elements, gas vents, metallic "tell-tale" indicator, and simplicity of construction with the addition of the auxiliary coil which fits inside the fuse case so that connections are made with the auxiliary connections outside of the case. They are made for both front and back connecting. The auxiliary coils connecting in shunt with the fuse in phase adjacent.

The National Multiphase Time Limit Renewable Fuse combines unusual economy with absolute safety and protection. It is made in all capacities from 3 to 600 amperes in both 250 and 600 volt.

Federal 3-30 Renewable Fuse Plug

Federal 3-30 Renewable Fuse Plug

The Federal 3-30 Time Limit Powder Packed Renewable Fuse Plug eliminates the quick blowing on momentary overloads and line surges, and because of its powder packed features and other superior points of construction would stand more blowouts than any other plug. It has the same time limit advantage as the fuses mentioned on this page. There is no porcelain to break. It has a strong molded insulated case with removable holder and powder packed cartridge. It is made in 3 to 30 amperes, 125 volts.

Approvals

Federal National Fuses are approved by:

The Underwriters' Laboratories, Inc.

Associated Factory Mutual Fire Insurance Companies.

Millers Mutual Fire Insurance Companies.

Hydro-Electric Power Commission of Ontario, Canada.

Bureau of Safety and all insurance companies.

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GREGORY ELECTRIC COMPANY

16th and Lincoln Streets, CHICAGO, ILL.

GREGORY ELECTRIC CO.
16TH AND LINCOLN STS. CHICAGO, ILL.

Used Electrical Machinery

The Pioneer Electrical Bargain House Since 1893

Who and What We Are

We are **primarily Electrical Machinery Merchants** and carry in stock an **enormous** quantity of **electric generators and motors,** principally used —all kinds, all makes, all types to suit all possible reasonable requirements. Every used machine offered for sale is a **bargain,** sold at less than the regular price.

Our buyers are particular to buy only late type modern machines in perfect condition. If there are any defects, such as a worn-out commutator, or defective bearings, these are replaced immediately before the machine is offered for sale. We guarantee every machine sold, **mechanically** and **electrically, as good as new.**

Our Facilities

We own our works, occupying one-half a block in the heart of Chicago's manufacturing district; have plenty of land for yard storage for lumber, coal and bulky material; have our own switch track connection with all railroads entering Chicago. We have our own power and testing plant, and generate our own electric light and heat.

Our works are so arranged that from the time a heavy machine is unloaded from a car on the switch track in our works, to the time it has been overhauled, refinished and tested, there has been no duplication of work in handling.

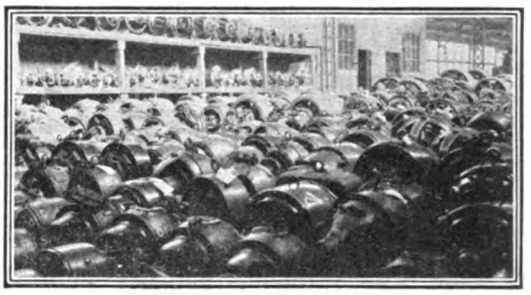
How To Order

Come to Chicago, if possible, and see the machine on the floor and inspect our works and processes, but if you can't come, don't hesitate to order by letter or telegram, as our machines are always as we represent them.

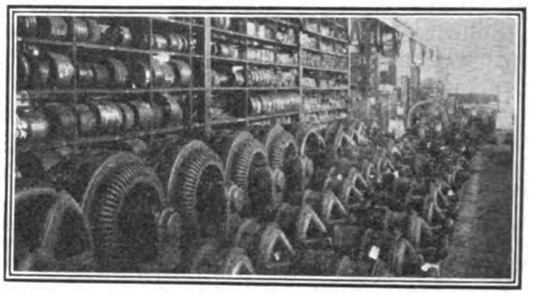
We sell the vast majority of our machines by mail, without personal inspection, to regular customers who are familiar with our methods and order from our Bargain Sheet.

Write Us

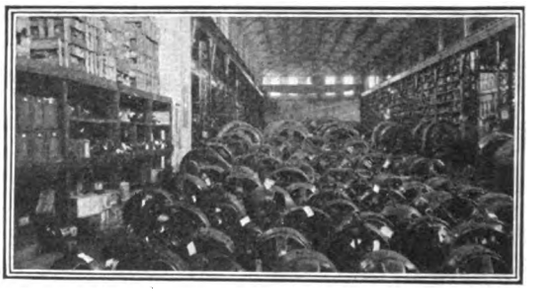
Correspondence invited. Send for our **"Monthly Bargain Sheet."** Always up to date. This shows complete stock on hand and NET PRICES. You will be surprised with the enormous stock we have on hand—all **standard makes** of the latest type and **all kinds.**



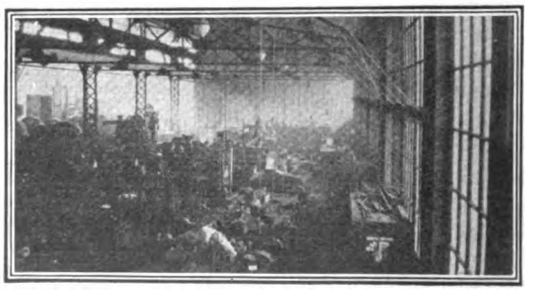
View in our warehouse. Note the enormous assortment of late type machines. The machines shown above are all direct current.



View in our warehouse. Alternating current motors. We buy only the best types. They are cheaper in the end than others, the first cost of which may be lower.



View in our warehouse. We know a good machine when we see it, and buy it only if it is a bargain. We believe in quick sales and small profits.



View in our repair shop. The largest and best equipped shops in this country.

NOTHING BUT BARGAINS IN USED ELECTRICAL MACHINERY

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THE SALT LAKE HARDWARE CO.

SALT LAKE CITY, UTAH POCATELLO, IDAHO

District Representatives for

CROCKER-WHEELER COMPANY

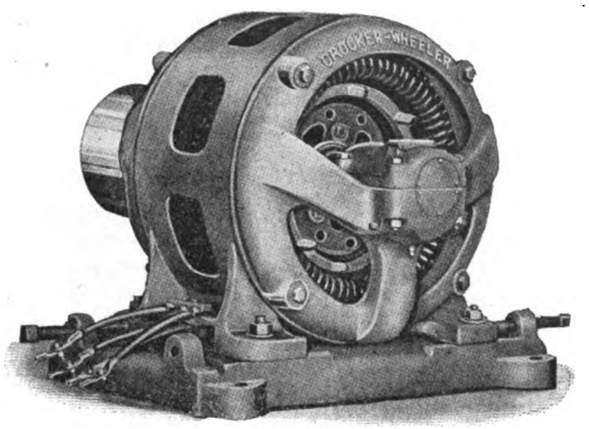
ELECTRIC MOTORS AND GENERATORS

The windings consist of form-wound coils heavily insulated, and small and medium sizes are subjected to a process of vacuum impregnation which enables them to resist the effects of moisture and acid fumes.

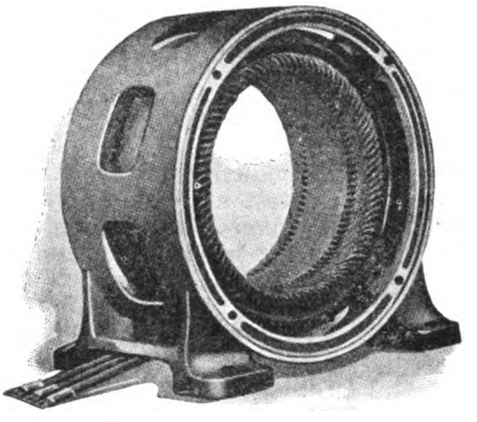
The windings are placed in open slots and are held in place by metallic slot-bridges which are separated from the core laminations by strips of thin but tough insulation.

The use of metallic slot-bridges results in a combination of advantages not otherwise obtainable. With open-slot construction, well insulated and mechanically rigid form-wound coils can be used. This greatly reduces the probability of electrical breakdown and at the same time facilitates repairs when necessary.

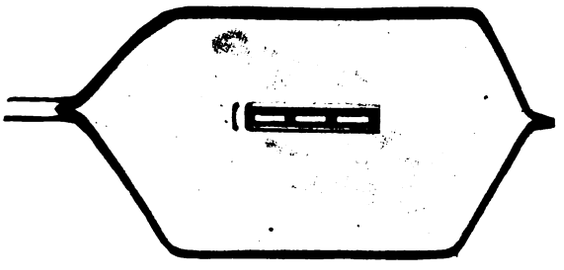
The metallic bridges, by producing a more uniform distribution of flux in the air gap, reduce the magnetizing current and hence increase the power-factor.



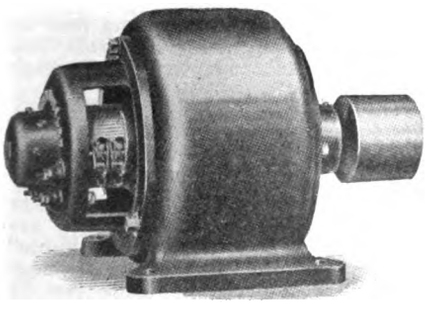
Crocker-Wheeler Form Q Squirrel-Cage Induction motors are designed for constant-speed operation on 60-cycle polyphase circuits.



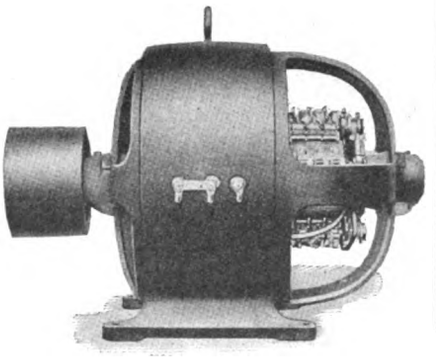
Stator Housing with Core and Windings, Form Q Induction Motor.



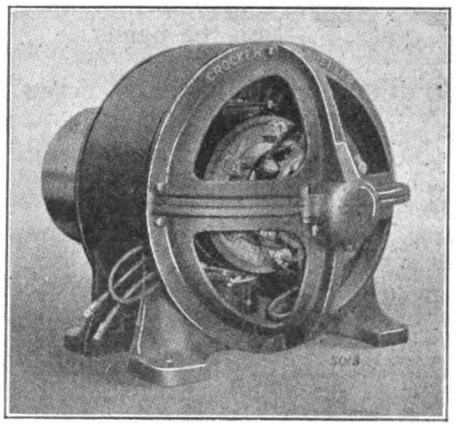
Form-Wound Stator Coil and two views of magnetic slot-bridge, Form Q Induction Motor.



Form L Direct-Current Machines. 115, 230 and 550 volts. Motors 1/5 to 7½ H. P. Generators 0.4 to 5 KW.



Form I Direct-Current Machines. Medium size for general use. Motors 3¾ to 50 H. P. Generators 3 to 45 KW.



Form H Direct-Current Motors and Generators. 50 H. P. and Larger. 125 H. P., 500 R. P. M., 230 V. Form H Commutating Pole Motor.

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RUBBER INSULATED METALS CORP.

General Offices
50 Church Street, NEW YORK

"RIMCO" Rubber Insulated Products

"RIMCO" Products

"RIMCO" Insulated Pliers.
"RIMCO" Insulated Screw Drivers.
"RIMCO" Insulated Flexible Couplings.
"RIMCO" Insulated Switch Handles.
Rubber Faced Pulleys.
Rubber Covered Rolls.
"RIMCO" Insulation.

RUBBER TRADE RIMCO MARK PRODUCTS REG. U.S. PAT OFF

Advantages of "RIMCO" Insulation Process

It is the **one** scientific method of **bonding** rubber to metal, thereby establishing a permanent chemical union between the two. In consequence the rubber cannot **work loose**—cannot **come off** and cannot **crack** or **break** upon hard impact, as it is a semi-soft compound.

The rubber compounds are of a high electrical resistance and are invaluable in high tension requirements.

Wherever it is desired that a rubber covering be **permanent** the "RIMCO" Bonding method will be found the **only one** to accomplish this end.

6", 7", 8", 9"

"RIMCO" Rubber Insulated Pliers

Fill a long felt want. They are all tested and passed by The Electrical Testing Laboratories of New York City, 10,000 volts, and each individual plier is stamped with its test statement. The insulation is semi-soft and, being permanently **bonded**, it cannot come off or crack if dropped on a hard surface or from the arm of a pole.

Invaluable to linemen, adding a tremendous margin of safety to rubber gloves, and are practically indestructible. For general use these pliers will be found preferable to metal handled ones, as they are much easier on the hands.

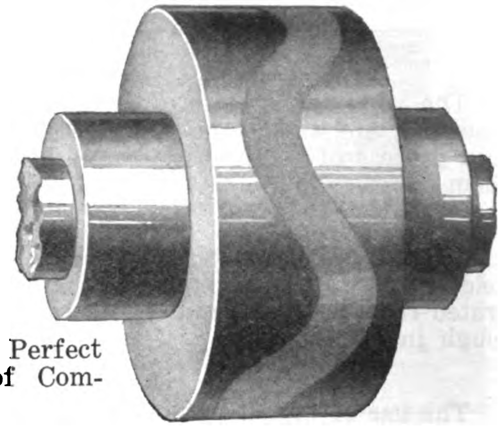
"RIMCO" Rubber Insulated Screw Drivers

Follow in the pliers' footsteps. Each one is tested and passed by The Electrical Testing Laboratories of New York City, 5000 volts, and is stamped accordingly.

The insulation is semi-soft and, being permanently **bonded**, it cannot work loose or crack. It is a beautiful tool and insures a remarkable grip, as the handle conforms to the hand. For both electrical and general use it is equally desirable.

7½", 8½", 10½"

"RIMCO" Insulated Flexible Coupling



The Only Coupling Approaching the Instant and Perfect Elasticity of Compressed Air.

They are especially adapted for connecting motors, generators, motor generating sets, air compressors, woodworking machinery, triplex or rotary pumps, line shafting, positive pressure blowers, **parallelling** gas engine alternators, etc., and in **absorbing fluctuations** in small gas engine driven lighting sets, for **suppressing flicker**, etc.

They have been tried out for years under severe conditions and are conservatively rated to take care of overloads for moderate periods without injury; also to take care of **variation alignment and expansion.** They permit mounting machinery on **separate foundations,** doing away with the necessity for a common base, thereby effecting a considerable saving in the cost of installation.

Angular variation is overcome, **"back lash"** is impossible, **torque is uniform** and **perfect insulation** is provided. Permits the armature to **float** in the **true field,** absolutely noiseless at all speeds. Requires no oiling.

Horse Power of the Different Sizes of the "RIMCO" Flexible Coupling and General Dimensions of Our Standard Sizes, the Horse Power Being Based on 100 R.P.M., From Which Any Other Speeds Can Be Computed

Outside Diam.	Standard Bore	Hub. Diam.	Length Over All		H. P. per 100 R.P.M.	Max. R.P.M.
			Articulated	Integral		
2"	5/8	1¼"	....	2 13/16"	.27	4500
3"	11/16	1¾"	3⅝"	3¼"	.9	4000
4"	1⅛ or 1 3/16	2¼"	5½"	5 "	2.1	4000
5"	1 5/16 or 1⅜	2⅝"	6 "	5¼"	4.3	3500
6"	1 9/16 or 1⅝	3 "	6½"	6 "	6.3	3000
7"	1¾ or 1⅞	3⅜"	7 "	6¼"	8.8	2500
8"	2 or 2 3/16	3⅞"	7½"	7 "	11.8	2250

Particulars regarding larger sizes transmitting up to 200 H. P. supplied on application. In ordering give diameter of shaft, key way, number of revolutions per minute and H. P. to be transmitted.

"RIMCO" Rubber Insulated Switch Handles

Tested to voltage required, are superior to any now on the market because the insulation, being semi-soft and permanently BONDED on the metal, cannot come off, crack

or break thereby endangering the life of the user. For use in mines and other places where switch handles are liable to being "whacked" in passing, their "unbreakable" composition renders them invaluable. They are being used in fast increasing numbers as their great value can be appreciated at a glance.

Inquiries Solicited From Supply Houses and Manufacturers

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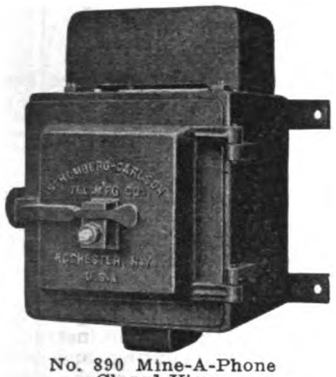
STROMBERG-CARLSON TELEPHONE MFG. CO.

ROCHESTER, NEW YORK CHICAGO, ILLINOIS
KANSAS CITY, MISSOURI
U. S. A.
TORONTO, ONTARIO

MINE-A-PHONE MINE-A-PHONE

The design of the Stromberg-Carlson Mine-A-Phone is the result of a thorough and extensive study of mine conditions and includes suggestions of many experienced mine engineers. No other telephone so completely meets the needs of underground service. It is a real mine telephone—built for the mine and not adapted to it.



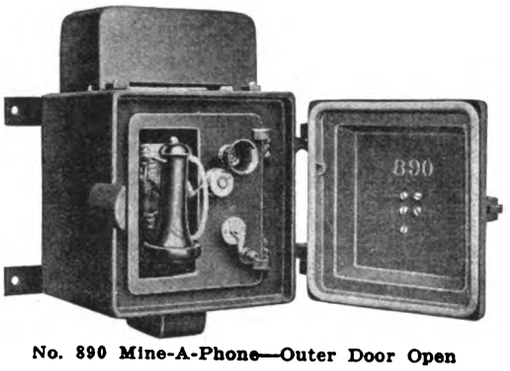
No. 890 Mine-A-Phone
Closed View

The No. 890 Mine-A-Phone consists of complete self-contained magneto telephone equipment arranged in a comparatively small iron case, finished in a black waterproof and acid-repellant enamel. The talking and signalling apparatus is placed within the inner compartment, where it is protected from moisture and gas and yet can be readily inspected or removed when necessary.

The door to the inner compartment is protected against the entrance of moisture by a wide overlap of felt, and the door is fastened shut by four machine screws. All openings through the inner case, such as required for the generator crank shaft, are protected by gaskets and packing.

The ringer is so arranged that the coils are inside the inner compartment, but the armature is outside the case and no holes remain through which water can enter the case. The ringer gongs and armature are protected by a cast iron dome which has an opening around its base through which the sound can be heard. The inner compartment need only be opened for the replacement of batteries, and this is seldom necessary.

When the outer door is opened the receiver, weather-proof linen cord, take-up device, transmitter mouthpiece and generator crank handle are exposed. The take-up device automatically takes up the slack in the receiver cord so that it will not be injured in the hinges of the outer door. The outer door is equipped with a rubber gasket, which renders the entire Mine-A-Phone water-proof, gas-proof and acid-proof when the door is closed. The case is high grade iron casting and will withstand fire and explosion. All coils are specially treated to resist moisture and all metal parts are protected by enamel or zinc plating.



No. 890 Mine-A-Phone—Outer Door Open

A feature that has recently been added to the Mine-A-Phone is the new push button lock on the outer door. This lock requires the use of but one hand to open it. Simply pressing the palm of the hand against the button releases the catch, the fingers grasp the handle and the door swings open. It is not necessary for a miner to drop his tools or whatever he may be carrying to use the telephone. A key lock may be supplied in place of the push button where it is desired to have only authorized persons use the Mine-A-Phone.

Two detachable mounting bars permit the Mine-A-Phone to be mounted on almost any surface. The actual dimensions of the No. 890 Mine-A-Phone are 10¾" high x 10" wide x 8½" deep.

Mine-A-Phone layouts, including circuit arrangements, types of surface telephones and switchboards, are furnished for each mining system as required. Write for Bulletin No. 1000, which clearly explains the Mine-A-Phone system in detail.

No. 890 Mine-A-Phone—Both Doors Open
Note Gaskets on Doors and Accessible Arrangement of Equipment

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FEDERAL ELECTRIC COMPANY

FEDERAL SIGN SYSTEM (ELECTRIC)

8700 South State Street, CHICAGO

91 New Montgomery Street, San Francisco — 130 W. 42nd Street, New York

Branches in All Large Cities

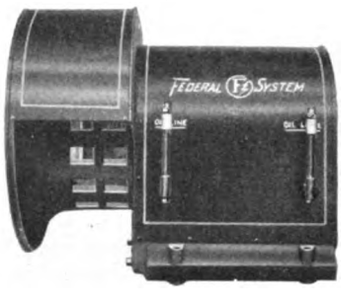
Product

Electric Siren Whistle.

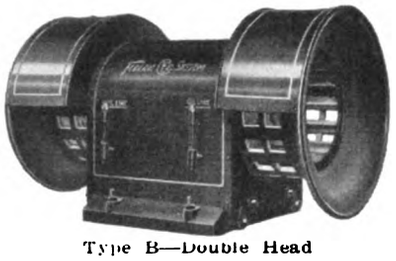
Type B siren is the ideal fire alarm signal or "start and stop" signal. It gives a weird screech that can be heard for miles around and cannot be mistaken for any other signal.

Type B, double head siren, makes double the volume of sound.

Type A siren is for use in factories, mines, etc., as a call signal.



Type B—Single Head



Type B—Double Head

DETAILS AS TO CONSTRUCTION, ETC.

Type	Class of Current	Motor H. P.
Single Head...	Single phase, 60 cycle, alternating current, 110 or 220 volts.....	2 H. P.
Single Head...	Two or three phase, alternating current, 110, 220, 440, 550 volts.	1½ H. P.
Single Head...	Direct current, 110 to 600 volts...	1½ H. P.
Double Head..	Single phase, 60 cycle, alternating current, 110 or 220 volts.....	3 H. P.
Double Head..	Two or three phase, alternating current, 110, 220, 440, 550 volts.	3 H. P.
Double Head..	Direct current, any particular voltage from 110 up to 600 volts..	3 H. P.
Type "A".....	Universal Motor, either A. C. or D. C., 32 volts up to 250 volts..	1/10 H. P.

All Sirens operate at a speed of 3,500 R. P. M. except Type A, which operates at 10,000 R. P. M.

We advise the installation of sirens to a 220 volt circuit, two or three-phase alternating current or direct current, wherever this current is available. A 220 volt circuit is kept up to the required voltage better than the 110 volt lighting circuit.

Type A

Special Motor

The above sirens with alternating current motors are for standard 60 cycle motors. Sirens to be operated on other frequencies, such as 25 to 45 or 75 to 133 cycles, require special motors with gear connections to siren to get required speed—Write for Special Price.

Construction

All sirens are constructed for outdoor service. Every part is thoroughly enclosed and absolutely damp and weatherproof. The motors are entirely covered by a heavy galvanized sheet iron hood. The rotor is made from heavy cast aluminum. The base is cast iron.

Lubrication

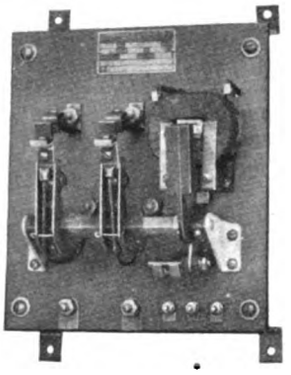
Each siren is shipped out with just enough oil in the vats so that it will not spill all over the commutator in transit. After a siren is installed for permanent use, the vats should be filled. For fire alarm use in small towns these sirens do not have to be oiled more than twice a year. For lighthouse work or other continuous duty, they will require more frequent oiling. Good clear machine oil should be used.

Finish

Each and every apparatus is painted with three heavy coats of paint, the last coat is a bright red enamel and nicely striped in black.

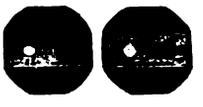
Guarantee

For fire alarm signalling work in small towns, factories, etc., we guarantee each siren for a period of ONE YEAR from date of purchase. For fog signalling or other continuous service our regular guarantee of ONE YEAR also applies.



Installation

Intelligible instructions for mounting and wiring are sent when the siren is shipped including a wiring diagram enabling any electrician to do the work right.



Remote Control Switch

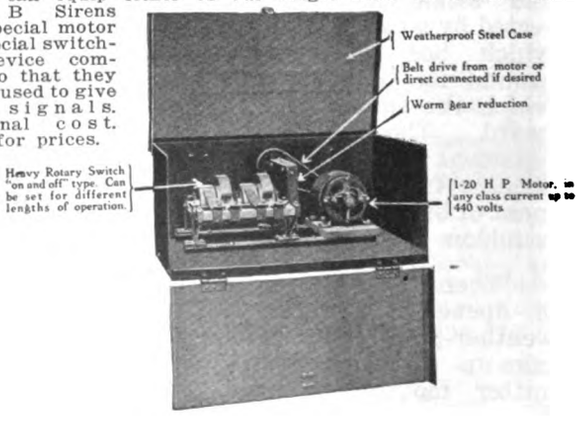
(See illustration above). The use of this device permits the Siren being operated from distant locations such as central telephone office, fire house, pumping station, etc. It consists of a suitable magnet operated circuit breaker and two momentary contact push button switches.

General Alarm Control

(See illustration below). The purpose of this control is to perform the on and off contact operation automatically, in place of the manually operated knife switch.

Special Siren

We can equip either of our single head or double head Type B Sirens with special motor and special switching device complete so that they can be used to give short signals. Additional cost. Write for prices.



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SECTION VI

Drilling and Underground Loading

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Bradley, C. C. & Son, Inc.
Chicago Pneumatic Tool Co.
Cleveland Rock Drill Co., The
Cochise Machine Co.
Cole-Goudie Shovel Co., The
Denver Rock Drill Mfg. Co., The
Dixon Valve & Coupling Co.
Goodrich, B. F. Rubber Co., The
Hardsocg Wonder Drill Co.
Hoar Shovel Agency, Inc.
Ingersoll-Rand Co.
Knox Manufacturing Co.
Lake Superior Loader Co.
Myers-Whaley Co.
New York Belting & Packing Co.
Sullivan Machinery Co.
United States Rubber Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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STANDARDIZATION OF DRILL-STEEL

Drill-Steels

Drill-steels, on which the greatest amount of investigation appears to have been effected, will be first considered, and at this stage it is desirable to summarize very briefly the report of the Mines Selection Committee.

On the results obtained from the 38 steels tested by Robert Allen the following conclusions were reached:

1. There is no practical difference in open-hearth, Swedish-bessemer, electric, or crucible steel, provided they are of the same composition.

2. Alloy steels are not as satisfactory as carbon steels provided the composition of the latter is in accordance with the figures given below:

Drills over 1½" diam. C 0.60 to 0.65%	Si, 0.05 to 0.15%
Drills over 1¼" diam. C 0.64 to 0.69%	S and P, 0.35% together
Drills over 1" diam. C 0.67 to 0.72%	Mn, 0.25 to 0.35%
Drills over ⅞" diam. C 0.70 to 0.75%	(Mn+Si, not over 0.40%)

Aluminum may be allowed up to 0.10%.

3. Steels which gave the best results on test had the following composition:

Drills 1⅛" diam	C	0.66%
	Si	0.09
	S and P	0.036 (together)
	Mn	0.28
Drills 1" diam	C	0.69%
	Si	0.09
	S and P	0.036 (together)
	Mn	0.30
Drills ⅞" diam	C	0.72%
	Si	0.09
	S and P	0.035 (together)
	Mn	0.27

The report further states that when using large bits on 1½-in. diameter drills there is a danger of de-carburizing the wings, and that such bits are difficult to harden properly, unless the carbon content is moderate—0.60 to 0.65% being suggested as the desirable limits. The presence of sulphur and phosphorus is condemned, and the limit for the total of these elements is fixed at 0.045%. Above this figure 'flaking' occurs, and 'cutting off' during sharpening becomes necessary.

4. Octagonal bars of the same steel made by hammering or rolling are equally efficient.

With regard to these various deductions, I am in agreement with the first statement. Provided that steels are of exactly identical composition, there is no valid reason why steel made in the acid open-hearth furnace should not be equally efficient as steel produced in the crucible. Unfortunately, however, from the financial point of view, steels made in the open-hearth furnace are rarely if ever as pure as the electric or crucible product, and the latter class of material therefore naturally commands a considerably higher price.

Two of the chief essentials for a good drill-steel are that it shall have a low manganese content and a minimum of sulphur and phosphorus. The last-mentioned elements are as much an enemy to the drillman as to the constructional engineer, and if present in appreciable percentage are liable to cause flaking, cracking, and fracture. A combination of much carbon and manganese is detrimental to the life of a drill, and many cases of failure can be traced directly to this cause. The presence of slag and other inclusions has led to innumerable fractures, not only in drills, but in all classes of steel used for engineering purposes.

The question now arises as to what shall constitute a desirable specification. One suggestion is as follows:

	%
C	0.85 to 0.90
Si	0.1 to 0.2
S	0.03
P	0.03
Mn	0.3 to 0.4

The central hole to be of the following dimensions:

Diameter of Drill	Minimum Diameter	Maximum Diameter of Hole
⅞ inch	¼ inch	5/16 inch
1 inch	9/32 inch	11/32 inch
1½ inch	⅜ inch	7/16 inch

and to be of such a size and shape that a steel ball equal in diameter to that of the minimum diameter of the hole, will pass completely through the bars. If the hole is elliptical the long diameter must not exceed the short diameter by more than 1/16 in., and the hole must not be more than 1/32 in. off centre from the axis of the bar. Seams and flaws will result in the rejection of the bars, which must be within the limits ± 1/64 in. on the finished size diameter. It would be interesting to learn how many drills at present in use would comply with these requirements, especially with regard to the eccentricity of the hole!

One Sheffield specification for hollow-steel drills from 1 to 1¼-in. diam. is as follows:

	%
C	0.75 to 0.80
Si	up to 0.20
S	not exceeding 0.02
P	not exceeding 0.02
Mn	not exceeding 0.3

These figures may be contrasted with the analysis obtained on a German hollow drill captured early in 1918:

	%
C	0.53
Si	0.09
S	0.044
P	0.048
Mn	0.80
Ni	0.07

The following analyses, made from samples of hollow drill steels 'as delivered', show how the composition may vary; and is an indication of the desirability, if not the necessity, for standardization:

	1 %	2 %	3 %	4 %	5 %
C	0.50	0.62	0.65	0.79	0.78
Si	0.12	0.10	0.10	0.03	0.18
S	0.048	0.045	0.043	0.038	0.018
P	0.050	0.044	0.044	0.007	0.010
Mn	0.37	0.36	0.41	0.23	0.32

All these steels except No. 5 were 1-in. diam., the latter being 1¼-in. The variation shown in the carbon and manganese on three samples from one batch of steel drills, which all fractured underground, further emphasizes the above remark.

	1	2	3
C	0.68%	0.72%	0.80%
Mn	0.21%	0.32%	0.31%

When considering a specification for drill steel the following points must be borne in mind:

1. The steel must be able to withstand percussive shock. Drills are frequently run at a speed of 1500 blows per minute, and the effect of rapidly-delivered strokes on a blunt drill in hard ground, where the cushioning effects of penetration are reduced to a minimum, can readily be imagined.

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2. The drill must be sufficiently high in carbon content to resist bending, hence the necessity for a higher carbon steel, with consequent higher elastic limit, as the drill diminishes in diameter.

3. The steel must be capable of being completely hardened by quenching; and, as unskilled and native labor is frequently employed on this job, a steel capable of simple heat-treatment is very desirable.

4. The bit must keep its full cutting diameter when in operation, and must therefore resist abrasion, or 'loss of gauge' and 'stuck' drills will result.

5. The steel must not chip or flake when in action.

From a consideration of these points it would appear that for a straight carbon steel, the carbon content should be approximately 0.70% for the best all-round service on a 1-in. drill; the percentage to be raised by 0.05 per 1/8-in. or lowered by 0.05 per 1/4-in., according as to whether the diameter is diminished or increased. The silicon content is not a matter of the greatest importance, and the modern tendency of steel making is certainly in favor of a much higher percentage than would be tolerated a few years ago. About 0.1 or 0.2% will be found satisfactory. The presence of sulphur and phosphorus has an important bearing on the mechanical properties of drills; and the effects of the latter are intensified as the percentage of carbon increases. The less of these elements the better, 0.03% being regarded as the desirable top limit for each, although plenty of drill-steel has given good service when these amounts have been increased to 0.05%.

Manganese should not exceed 0.3% unless the carbon content is low; and a limit of 1% for Mn + C is suggested. I entirely disagree with the use of aluminum, and in no circumstances should a percentage of 0.1 be tolerated. The present tendency of Sheffield manufacturers is to dispense with its use, and ferro-silicon is now substituted as a killing agent with more satisfactory results.

A point which has hitherto been ignored is the formation in the hole in the drill. The bulk of the hollow drill-steel imported into this country is probably mandrel-rolled, whereas English-made drills are usually core-rolled. There seems to be little doubt that the latter method produces the best drill, as the circumference of the central hole is less liable to surface cracks which may extend in service and ultimately cause breakage.

With regard to alloy steels there appears to be very few data to prove their advantages or disadvantages. Allen states that "such steels are not equal to the best carbon steels on account of their tendency to overheat and their lack of uniformity of composition". Further, he remarks that "the heat-treatment of chromium steels is not simple, and the drills are liable to deteriorate". Vanadium steels possess no advantage whatever over carbon steels and are more costly. Drills are better without tungsten, which renders the steel liable to crack on heating and imparts brittleness and difficulty in forging. Finally, Allen considers the fine grain of tungsten steel detrimental, as the finer the grain the less the resistance to drilling shocks.

On the other hand, Harbord† states that a small addition of tungsten has been found to improve the wearing properties of some classes of chisel steel. For example, a steel of the following composition gave good results for the working of pyrites, whereas a steel of similar composition without the 1/4% addition of tungsten failed in a competitive trial:

	%
Fe	98.40
C	0.63
Si	0.126
Mn	0.522
S	0.006
P	0.034
W	0.241

A steel containing 0.57% C, 0.21% Si, and 0.325% W also stood this class of work well, where a higher-carbon steel without tungsten failed to do the work satisfactorily.

The only conclusion that can be drawn from these conflicting statements is that Allen must have been singularly unfortunate in his deliveries of alloy steels or else they must have been grossly maltreated. From theoretical considerations, it would appear probable that both chromium and tungsten steels would have considerable advantages in reaming efficiency and reduced attention. It is difficult to understand why such steels should be complicated in their heat-treatment. Forging, however, is probably slightly more difficult; and any tendency to brittleness might be accentuated. A promising field for research is opened at this point, and in the absence of comprehensive and comparative data it would be unwise to dogmatize.

By E. A. Wraight. A summary of an investigation by Robert Allen for the South African "Mines Trials Committee."

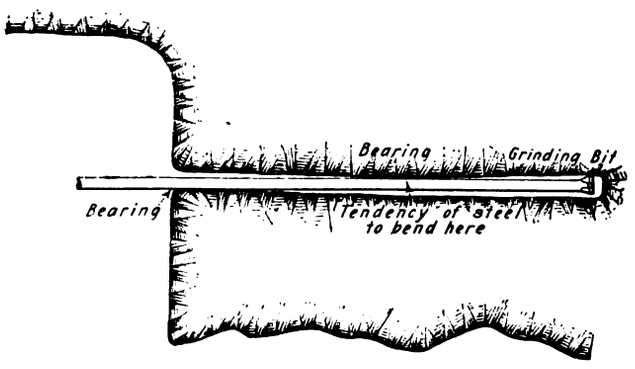
†"Metallurgy of Steel." 1916 edition, p. 414.

STUCK STEEL

One of the principal troubles that cause difficult drilling is stuck steel. Drill steel becomes stuck for the following reasons:

1. Improper alignment of drill steel and hole.
2. Incorrect type of bit.
3. Incorrectly formed bits.
4. Feeding too much or too little water.
5. Weak drill rotative power.
6. Worn or broken shanks.
7. Worn or broken drill parts.
8. Drilling into a seam or in "fitchery" ground.
9. Pebbles falling behind bit or mud collar forming behind bit.

A common cause of stuck steel is the improper alignment of the drill steel with the hole. When



Steel and Hole Out of Alignment

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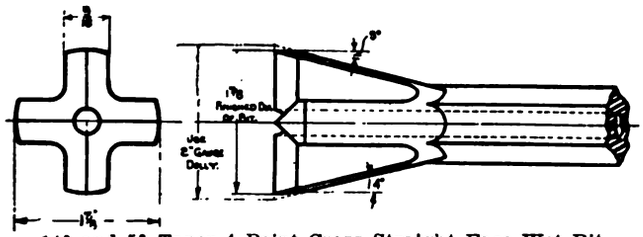
this occurs the drill steel will bear on at least two points in the drill hole. There is a tendency for the steel to bend, increasing with the divergence from true alignment, and a severe grinding on the reaming surfaces of the bit. All of this will cause difficult rotation and will, in many cases, stop rotation entirely.

This condition is due to poor operating. The steel must be brought nearly into line to have it enter the hole. The experienced drill runner can line up the drill laterally "with his eye." He will do this after entering the steel and cranking it nearly to the cutting face, and tighten his "tee-bolt nut." He will then open the throttle (inlet) valve a little, and let the drill find its own vertical line, helping it a little by raising up on the crank end, and finally tightening the clamp bolt nut. If the hole is very much out of line time can often be saved by abandoning it entirely and starting a new one.

The choice of the proper type of bit is important in helping to eliminate stuck steel. For example, a narrow rapid-cutting chisel bit would bury itself in some soft limestones. Six-point bits are usually in disfavor because of their slow drilling and small clearance space for the cuttings.

The cutting edge has the greatest diameter on a single taper bit. This cutting edge wears rapidly, and soon the diameter is less than at another point farther back on the bit. Then the hole cut by the cutting edge is too small to admit the rest of the bit and a reaming action takes place which will soon stall the rotation and stick the steel. To overcome this many and varied designs of bits have been made, some of which were extremely complicated, and if they have any advantage underground, the time taken by the blacksmith to make them and resharpen them more than outweighs this advantage.

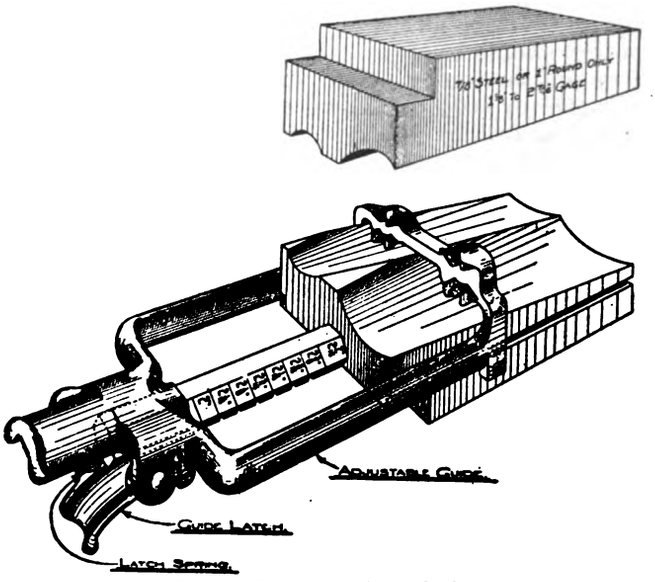
The bit that has been found most successful for rapid cutting, long-wearing gage, and ease of making and resharpening is the 14 deg. and 5 deg. double-taper cross or four point. This double-taper bit when properly made has a reaming surface whose diameter is the same as the diameter of the cutting edge and which backs up the latter with a good stock of metal, increasing the life of the gage. It also acts as a guiding surface, preventing the steel from running off into seams or fissures. The use of this type will, in the majority of cases, remedy any trouble caused by wear of gage.



14° and 5° Taper 4 Point Cross Straight Face Wet Bit

It has already been said that the bits should be properly made. That leads to consideration of the methods of making and sharpening drill steel and their bearing upon stuck steel. Primarily, there are two methods of sharpening drill steel, by hand and by machine. The latter method is by far the more rapid, accurate, and satisfactory, and should be used wherever three or more drills are in operation. However, even machine-made bits are sometimes faulty. This is usually due to careless blacksmithing, because the machines are extremely simple and rugged and, should they get out of adjustment, it is a relatively easy matter to put them into proper condition again.

The manufacturers of drill-steel sharpeners are continually making the machines more nearly foolproof. One of the latest improvements for assuring better bits is the use of double-bored gaging blocks with an adjustable latch guide. The wide range of these blocks permits the operator to gage accurately an entire normal run of steel on the one set of blocks, and these adjustments for the various gages require only the pressure of a finger on the adjustable latch guide.



Double Bored Gaging Blocks

An interesting but less common cause of stuck steel is the feeding of too much or too little water through the hollow drill steel. When too little water is fed a mud collar frequently forms behind the drill steel, which makes it difficult to extract the latter. Sometimes when drilling into rock bearing metallic ore, and too much water is fed, a mineral separation takes place. The gangue is sludged off, and the drill pounds away ineffectively on the metallic residue, finally becoming stuck. Sometimes dry drills are run in abrasive ground. The steel soon heats up, and the temper is rapidly burned out of the bit. This condition may be remedied by using a water feed or a wet drill.

Sometimes the shank portion of hexagon steel becomes so worn that it permits the steel to slip in the rotative sleeve, or the lug on round steel becomes worn or broken off, with the same result. The drill steel will then be hammered into the ground without rotating and will soon become stuck. The only remedy for this is to keep the shanks in proper condition. The same results are obtained when use is made of worn or broken drill parts, principally worn pawls, chuck and bushings, and broken pawl springs and rifle bars. The only remedy for this fault is to replace the worn or broken parts.

The rotation of some drills may be too weak for the rock conditions. This, however, is exceptional, because rock-drill manufacturers have strengthened the rotative power of the drills up to a practical limit. Frequently, drill trouble is attributed to weak

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rotation when that is far from being the true cause.

Unequal cutting may easily take place when drilling into a seam or in fitchery ground, and this throws the steel out of line and sticks it. Drilling into brecciated ground sometimes causes pebbles or small bits of rock to fall behind the bit, and those wedge against the steel and the drill hole, stopping rotation. In some limestones and other calcareous formations the water mixing with the cuttings will form a mud collar back of the bit.

In all of these instances mentioned it becomes a question of loosening and removing the stuck steel. There is one popular method of performing this operation that should not be followed, and that is to pound away on the drill steel with a 16-lb. double jack. This manner of loosening the steel is common, but usually the only real results obtained by it are bent steel, broken drill parts, strong back, and increased vocabulary. Usually the steel itself stays stuck. Another method, advocated for obvious reasons, has to do with the proper lubrication of the machine. When the steel is stuck, fill the back and front cylinder pockets with oil, open the throttle and 99 per cent of the time the steel backs out of the hole without any further trouble. A slight blow loosens the drill steel and properly lubricated rotative parts take care of the rest.

The increased ease of operation and the greater speed of drilling of properly lubricated drills should convince the operator that this matter ought to be properly considered. Unfortunately a great number of operators still think that axle grease is good enough, others think cylinder oil will do, and others don't think.

Representatives of either oil companies or rock-drill manufacturers are always pleased to consult with and give to mine operators the benefit of expert knowledge and long and varied experience.

Abstracted from article by D. E. Dunn, of Ingersoll-Rand Company, written for Engineering and Mining Journal.

Ideal Shop For Sharpening Drill Steel

Primary Requirements of a Sharpening Plant

Primarily a drill-steel plant having one mechanical sharpener should be designed so that the output of the smith and his helper may be doubled by the addition of two men, without any increase in the original shop equipment being necessary, and to provide for possible growth, it should be so constructed that by adding space and certain features of equipment to one end only of the building the capacity may be increased further at slight expense without making any change in the original equipment; that the various operations required to make the drill steel and to reforge and temper used steel are performed with the fewest possible movements and with the least amount of exertion on the part of the operator; and that the character of the work when executed conforms with the established standard for the existing conditions.

To secure these results the building should be of such size that the various machines and their appurtenances may be placed in the most advantageous position. It should be built of materials that are accessible and in conformity with the standard surface equipment of the mine. It should be lighted in such a manner that the piece being worked upon and the operating end of the machine employed are clearly visible to the operator, so that his vision of the parts is not obstructed by shadows; in addi-

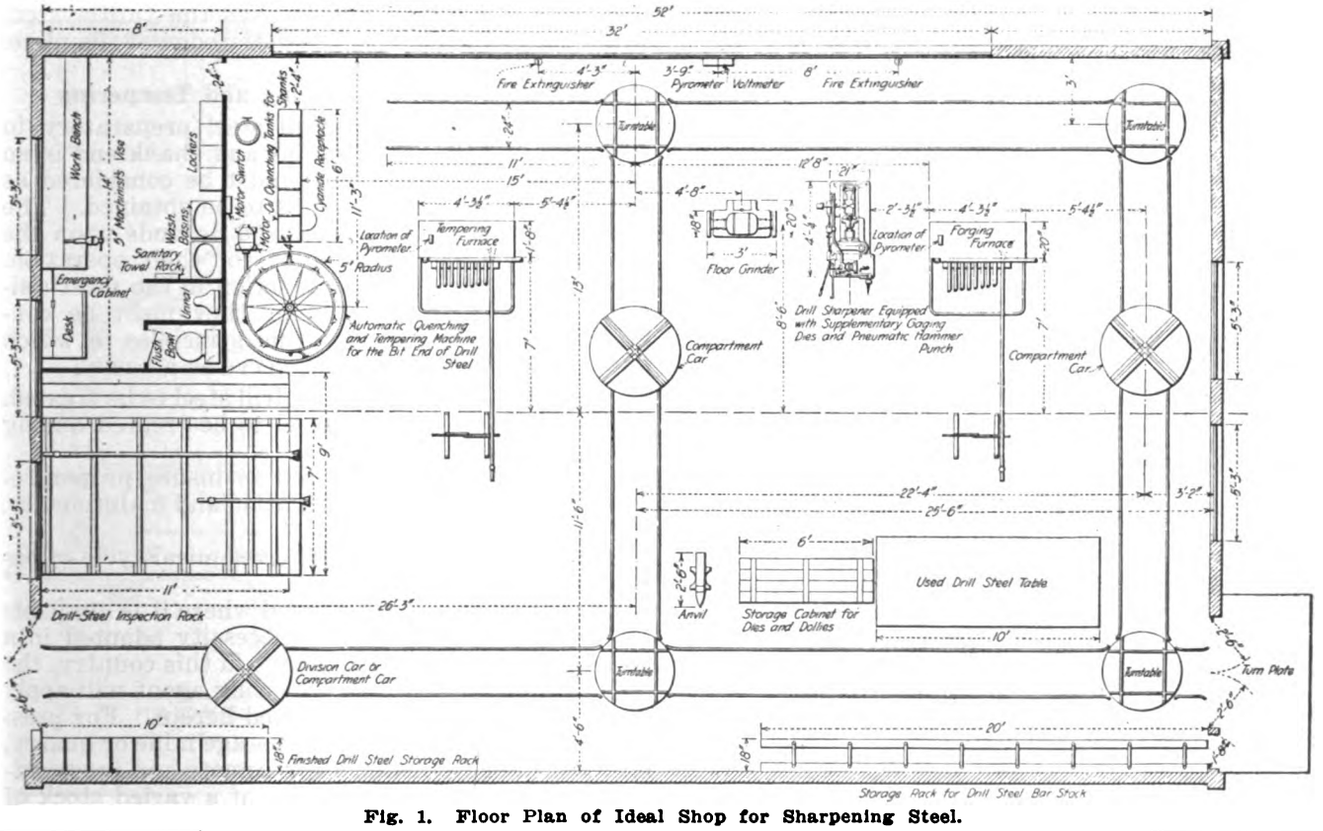

Fig. 1. Floor Plan of Ideal Shop for Sharpening Steel.

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tion, to meet the requirements of a shop of the size and type herein described, certain features of equipment are recommended in Table 1.

In order to obtain maximum efficiency in a drill-steel plant it is essential that the transportation of the drill steel be accomplished expeditiously and with a minimum effort, for, regardless of how suitable the mechanical equipment may be, it is impossible to secure and maintain maximum production from the machines and furnaces if a suitable means of transportation conforming to the requirements of the plant is not provided.

To meet the requirements of the type of plant described in this paper it is recommended that the shop, Fig. 1, be equipped with a permanent track and turntable, the gage of which corresponds to the standard gage of the mine or quarry tracks, provided such gage does not exceed 36 in. For transporting the drill steel to and from the shaft, or loading platform, a division car of the Copper Queen type, Fig. 2, described in the Engineering and Mining Journal, June 24, 1916, will be found to meet the requirements satisfactorily. This car may be equipped with a body detachable from the truck to facilitate the work of transferring the drill steel to the mine skip, cage or wagon without removing the bars from the receptacle, or it may be employed for the purpose intact, and in the case of the mine the whole may be lowered to the different levels where the distribution of the steel may be made in conformity with standard practice. Of the many forms of carriages or trucks employed for the transportation of the drill steel while it is in the transition stage during the process of working, that developed by the Copper Queen Consolidated Mining Co., and described in the article referred to, is perhaps best adapted for a drill-steel plant of this general type.

The compartment car, Fig. 3, consists of a truck having the wheel gage corresponding to the track standard, on which is mounted a revolvable compartment body supported by a ball bearing and equipped with a latch for locking the body with relation to the truck in any desired position. This car is employed for transporting the steel from the sorting table and the oil-quenching tank to the heating forges. In it the various lengths of steel are segregated and by virtue of the revolvable body the insertion and removal of the drill steel is accomplished advantageously. Subsequent to the final heating of the bit the steel is transported mechanically by the tempering machine and deposited upon the inspection rack, Fig 4, whence it is loaded into the division car and transported from the shop.

The four turntables with which the track system is equipped provide means for the cars to be bypassed at any point except the dead end and, by having the main line extend through the building longitudinally, a convenient means is provided whereby the track system of the shop may be in intercommunication with the yard system and the other departments of the mine plant. At the outside of the building adjacent to the main entry a turn plate is provided, composed of boiler plate ⅜ in. thick, to facilitate the switching of the cars to and from a series of tracks from the yard system which may terminate at the outer edge of the plate.

TABLE I. EQUIPMENT FOR DRILL-STEEL SHOP.

Transportation
106 ft. of 24-in. gage track (rail 35 lb. per yd.) comprising 86 wood ties 4 x 6 x 36 in.
4 Mine-car turntables—24-in. gage.
1 Turntable (if required).
3 Compartment cars with revolving body (Copper Queen type).
3 Division cars with detachable body (Copper Queen type).

Furnace
1 Forging furnace (oil or gas burner).
1 Tempering furnace (oil or gas burner).
2 Drill-steel supports for furnaces.
2 Ventilators with hoods for furnaces.
1 Oil storage tank.
1-in. pipe with fittings for low-pressure air supply.
½-in. pipe with fittings for fuel supply.
2 Pyrometers, equipped with base metal couples having indicating voltmeter and cabinet.
¾-in. electrical-conduit piping (for pyrometers).
2 Pyrene fire extinguishers.

Sharpener
1 Drill sharpener with full equipment of dies and dollies including supplementary gaging dies and pneumatic-hammer punch.
1¼-in. pipe with fittings for compressed-air supply.
1 Storage cabinet for drill-sharpener appurtenances.
2 Suspended drill-steel supports (for sharpener and grinder).
1 Floor grinder (direct electric-driven) with two grinding wheels 18 x 3 in.
1 Electric switchboard for motor.

Tempering
1 Rotary quenching and tempering machine (Homestake type), with 1 H. P. motor.
1 Electric switchboard for tempering-machine motor.
1 Oil-quenching tank with syanide receptacle.
1 Ventilator with hood for syanide receptacle.

Racks, Tables and Accessories
1 Inspection and bundling rack with incline, equipped with one gage cabinet.
1 Storage rack for drill-steel bar stock.
1 Storage rack for finished drill steel.
1 Used steel table.

Sanitary Equipment
1 Sanitary drinking fountain.
4 Steel double-deck lockers.
2 Wash basins.
1 Sanitary towel rack.
1 Urinal.
1 Flush bowl.
1 Emergency cabinet.

General Equipment
1 Work bench equipped with 5-in. machinist's vise.
1 Desk with drawers and hinged top.
1 300-lb. anvil.
1 Set of hand chisels and sledges.
2 500-watt Mazda lamps with reflectors.
1 60-watt Mazda lamp with reflector.
Water piping.
Compressed-air piping and hose equipped with Davies blow-gun.
Waste piping.
Oil piping.
Electric wiring.
Concrete floor.

Heating Furnaces for Forging and Tempering

The heating of rock-drill steel preparatory to forging and tempering the bit and shank end is an engineering problem and it must be considered as such if maximum efficiency is to be obtained. The success of the furnace employed depends upon the type and the method adopted for their operation. In order to perform their function in the most uniform and economical manner they must be constructed according to scientific principles in which the following considerations serve as a basis:

1. Size and shape of the drill steel to be treated.
2. Quantity of drill steel to be treated during a specified time.
3. Temperature required to insure proper results, and means for its regulation and maintenance.
4. Local conditions.
5. Most convenient and economical cycle of operations.

Gas as fuel is recommended where it is available at low cost but as oil is of necessity adopted in a large majority of mining camps in this country, the employment of either as a heating agent will apply to the type of furnace described herein. For present-day requirements of the average mine or quarry, situated in many instances in remote and inaccessible places, where the carrying of a varied stock of

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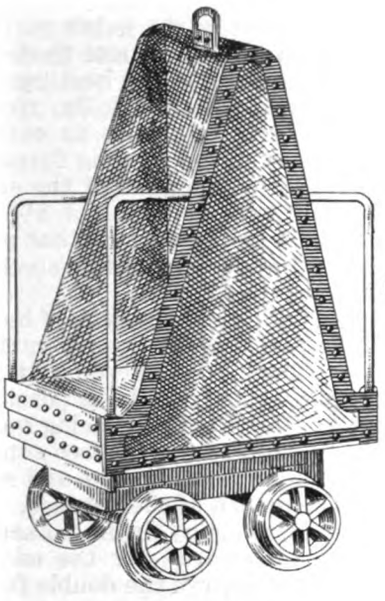
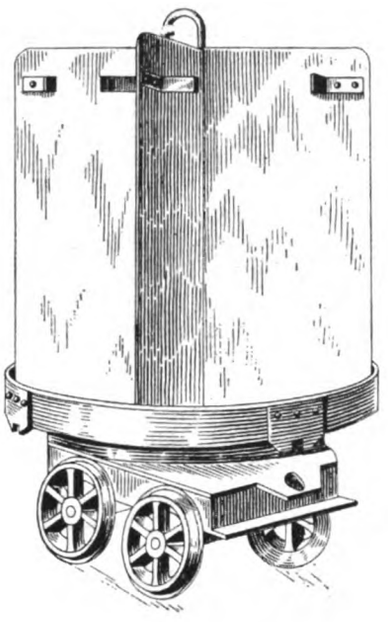
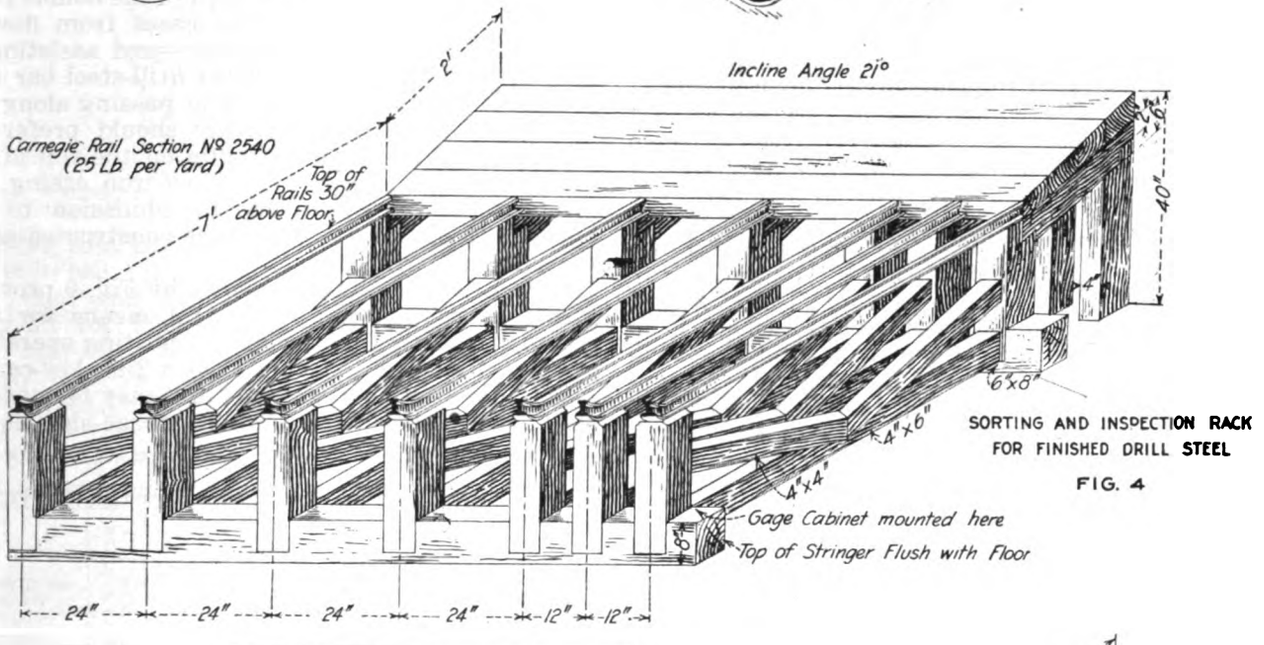


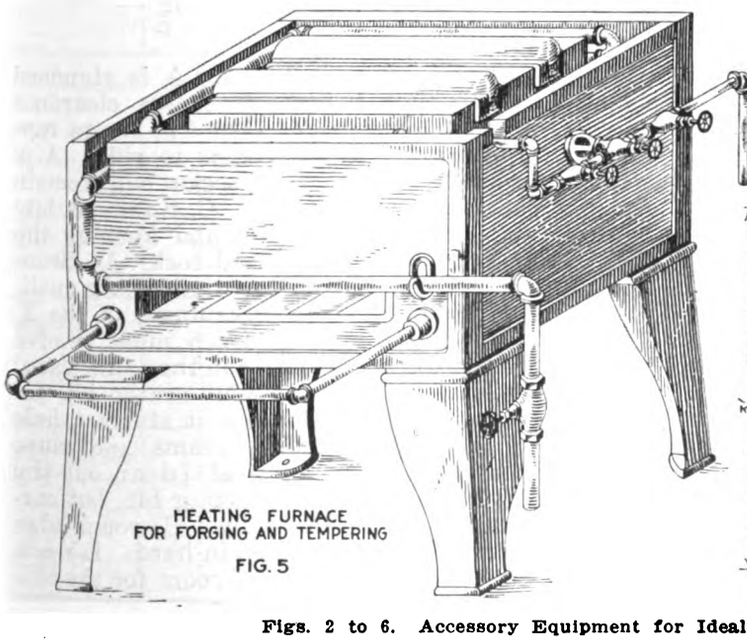
DIVISION CAR
FIG. 2



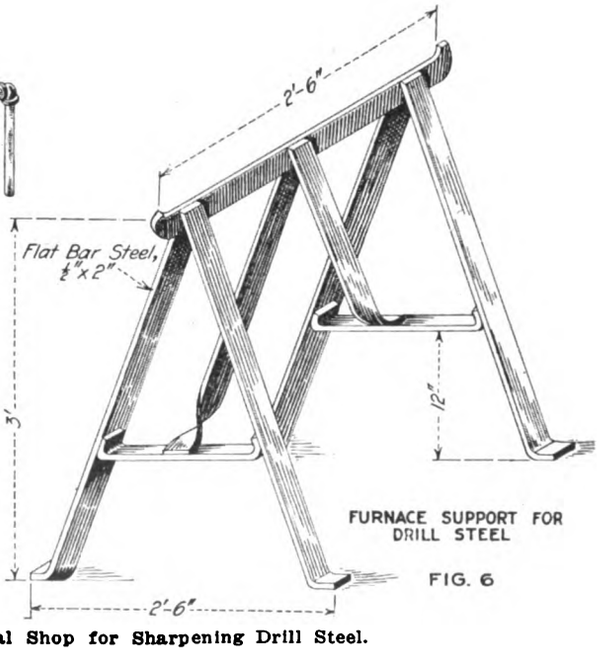
COMPARTMENT CAR WITH REVOLVABLE BODY
FIG. 3



SORTING AND INSPECTION RACK FOR FINISHED DRILL STEEL
FIG. 4



HEATING FURNACE FOR FORGING AND TEMPERING
FIG. 5



FURNACE SUPPORT FOR DRILL STEEL
FIG. 6

Figs. 2 to 6. Accessory Equipment for Ideal Shop for Sharpening Drill Steel.

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refractory material is not only difficult but also expensive, simplicity of furnace design with special regard to repairs should be considered primarily. With this in view the refractory material used in the construction of a furnace should be composed solely of standard-size firebrick, procurable in almost every local market, and it should be assembled in such a manner as to enable any blacksmith to repair or rebuild it with ease and success.

The heating chamber of the furnace should preferably be of such size and shape, and its burner so positioned, that the steel is heated by reflection or radiation rather than by direct impingement of the flame on the metal. This will prevent blistering and reduce the formation of excessive scale which is likely to result if the flame is caused to play directly on the metal. The heating chamber should be of such size as to absorb economically the heat of the products of combustion.

A certain amount of flexibility that may be taken advantage of by an untrained operator is desirable, inasmuch as the character of the flame required for heating, to the best advantage, standard types of 7/8-in. hexagon and 1¼-in. round hollow steel will vary with the size of the bit and the shape of the drill shank; and, in the case of the lugs or collars on the shank, will require only the heating of that portion to be upset, without affecting the extreme end of the bar, and thus obviate the necessity of cooling the tip before it is inserted in the dies of the drill sharpener. This flexibility may be secured by employing a burner of such construction that a perfectly round or fan-shaped flame is produced at will by the operator by merely adjusting a thumb-screw. Another desirable feature of such a furnace is to have at the end of the chamber from which the drill steel is withdrawn a maximum heat zone of constant and uniform temperature, from which the temperature is lowered gradually but to an appreciable degree toward the end opposite where the steel is inserted. This will give the steel time to absorb the heat gradually, and will secure uniformity in the opening of the grain as the steel bars are handled in rotation.

It has been determined by experiment that the time period of 4 min. is desirable for heating the larger sizes of bits formed on the 1¼-in. round hollow drill steel and in order to insure an output of one steel every 30 sec. from the forging furnace, the mouth or opening for the insertion of the steel should be 2 ft. 6 in. long with a height of 3½ in. Pyrometer readings should be taken from that part of the furnace directly adjacent to the drill steel at the point of withdrawal.

To obtain the best results from any type of burner in point of economy and ease of operation it is of prime importance to have both the oil and the atomizing agent as constant and steady as possible. After passing through the pressure-reducing valve it is desirable to have the air for the furnace supply pass through a pipe mounted directly over and running lengthwise with the mouth of the furnace. In this pipe provision may be made by drilling a series of small holes directed downward—for the escape of a part of the air which will serve the double function of preventing the waste gases from flowing out in the face of the operator—and assisting in keeping cool that section of the drill-steel bar that projects from the furnace. After passing along the mouth of the furnace the air should preferably make two three-quarter circuits on the top of the brickwork, but inside of the cast-iron casing, for pre-heating it, preparatory to admission to the burner. Fig. 5 shows a furnace constructed along these lines.

The drill-steel support shown by Fig. 6 provides a simple, rugged and convenient means for supporting the drill steel during the heating operation. Constructed from flat bars of ½ x 2-in. low-carbon machinery steel or wrought iron it may be made by any blacksmith with an ordinary forge-shop equipment.

From article by George H. Gilman, formerly with Sullivan Machinery Company, in Engineering and Mining Journal, October 6, 1917.

NOTES ON DRILLING

Drill Steel

Octagonal steel is mostly used. Gage of bit varies from 200% of width of shank for soft rock, to say 130% for hard; chisel edge is generally used for hand drilling, and Cross, X, Z, and other shapes for machine drills. Size of hole in hollow steel is assumed at .25 in. Actually it varies with size of steel and with specifications.

Hand Drilling Bits

Steel is usually ¾ to 7/8 in. For soft rock, 5/8-in. steel may have a 1-in. bit; 7/8-in. steel, a 1.25-in. bit. The chisel edge of a hand bit is usually convex; its faces should be at 90° for hard rock, and about 45° for soft; in sandstone a blunt edge cuts faster. Gage of bit decreases as length of shank, or depth of hole, increases. The reduction in gage depends on hardness of the rock. In soft rock, the bit wings wear slowly, and the decrease in gage is less than for hard rock. Reduction in gage is commonly 3/32 to 1/8 in. per bit.

Machine-Drill Bits*

Fig. 1 shows different shapes. A is standard American cross-bit. B has an excess clearance angle (16°) and round edges (see A); wears rapidly on the corners, and hole tends to rifle. A is stronger than B, and in soft rocks will remain sharp about four times as long. C, Simmons bit: 2 wings are solely for reaming and keeping the hole round; a rapid driller in hard rock. D, Brunton bit, which combines the easy sharpening qualities of the cross-bit with the advantages of the X. E is the X-bit, the wings of which must revolve 180° for the edges to strike twice in the same place; this prevents rifling. F is a high-center bit, favored for hammer drills, because it starts a hole easily; but it is apt to follow seams and cause crooked holes, and does not mud (clear out the cuttings) freely. G is a fast-cutting bit, but corners dull rapidly and break easily. H, round-edge bit, is good in soft rock but rifles in hard. I, Y-bit, muds freely, as there is plenty of room for the cut-

*T. H. Proske, Min. and Sc. Press.

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tings to escape; difficult to sharpen by hand. J, bull or chisel bit, formerly used for hard rock in Missouri and still sometimes used in marble quarrying; has been superseded by power-sharpened X-bit; cuts fast in a seamy shale with a water jet.

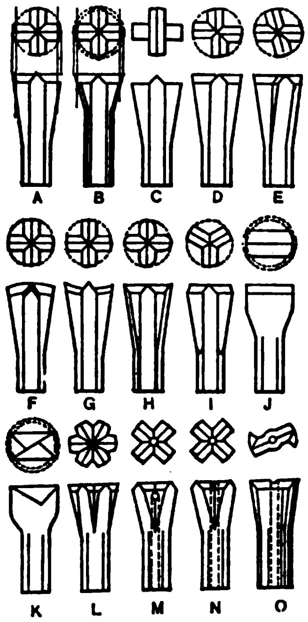

Fig. 1. Shapes of Machine-Drill Bits.

K, Z-bit, sometimes employed where hand sharpening is in use. L, 6-wing rosette, made with power-sharpener and used for hammer-drills only. M, cross-bit for hammer-drills. N is the same bit, with hole at center instead of at side. O is a Z-bit widely used in Germany, usually with a spiral twisted shank.

SHAPES AND DRILLING SPEEDS OF HAMMER-DRILL BITS

Description of bit	Duration of run, minutes	Diameter of hole, inches	Aver. in. drilled per run, 70-lb. air pressure	Aver. in. drilled per run, 85-lb. air pressure	Remarks
25° diamond point +...	2	1⅝	6⅝	8½	Spots easily. Hole rifles slightly. Rotation easy. Gage holds well.
25° diamond point X...	2	1⅝	6	7¾	Spots easily. Drills round holes. Rotation easy. Gage fairly durable.
Convex +...	2	1⅝	6⅛	8¼	Spots easily. Hole rifles slightly. Rotation easy. Gage holds well.
Flat +.....	2	1⅝	6	7½	Difficult to spot hole. Hole rifles badly. Rotation hard. Gage fairly durable.
4° concave +....	2	1⅝	5¾	8¼	
25° pointed Bull —....	2	1⅝	5¾	7	Spots easily. Drills round hole. Rotation easy. Gage wears rapidly.
Flat Bull —	2	...	5 11/16	7¼	Difficult to spot hole. Hole rifles badly (3 flutes). Rotation hard. Gage wears rapidly.

Courtesy Sullivan Machinery Co.

Arrangement of Drill Holes in Tunnels

The arrangement of drill holes is influenced by local conditions, but nearly all the systems adopted in American mining tunnels and drifts may be classified under three heads, according to the type of cut employed.

The "cut" or "cut holes" are those which are pointed in such a manner that, when blasted first, they remove a core or wedge of rock from the solid face, thus decreasing the work to be done by the remaining holes.

The wedge or "V" or center cut, the one most commonly employed, consists of several pairs of holes directed toward each other from opposite sides of the heading. They break out a wedge-shaped prism, usually extending from floor to roof. Figs. 2, 2a and 3 show several arrangements of

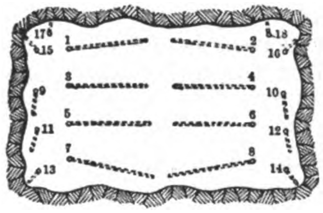

Fig. 2. Wedge-Cut Round of Holes.

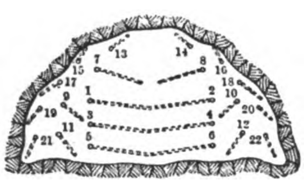

Fig. 2a. Wedge-Cut Round for Arched Headings.

wedge cuts. In Fig. 2, holes 1 to 8 comprise the cut and are blasted simultaneously. Side holes 9 to 14 are next fired together, the back holes 15 to 18 being fired last. In Fig. 2a, the cut holes 1 to 6 are blasted together, followed by relievers 7 to 12 and finally by trimming holes 13 to 22. Fig. 3 shows arrangement with horizontal-bar mounting.

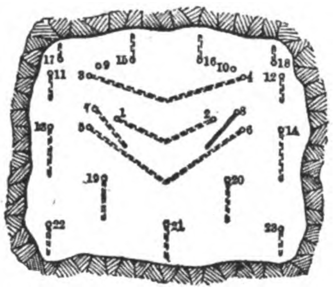

Fig. 3. Wedge-Cut Drilled from Horizontal Bar.

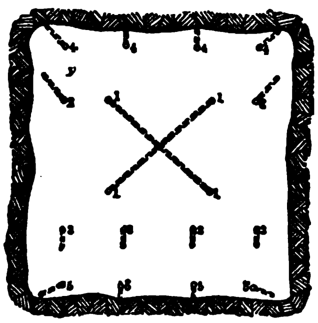

Fig. 3a. Pyramid Cut.

Holes 1 and 2 are "short-cut holes"; 3 to 6 are "long cuts"; 7, 8, 9, 10, 19 and 20 are "relievers"; 11 to 14 are "sides"; 15 to 18, "backs"; and 21 to 23, "lifters"; the numbers indicating the order of the blasting.

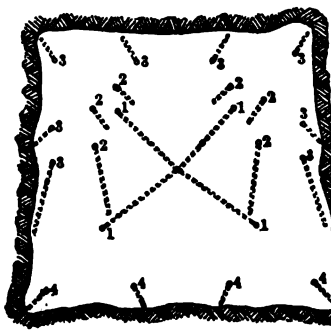

Fig. 4. Pyramid-Cut Round Drilled from Horizontal Bar.

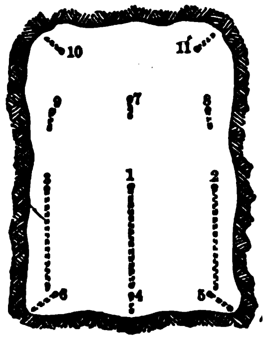

Fig. 4a. Bottom-Cut Round.

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The pyramid cut consists usually of four holes drilled so that they actually or nearly meet at a common point (generally near the axis of the tunnel), which, when properly blasted, remove a more or less pyramidal core. Figs. 3a and 4 show two arrangements of this method. The numbers showing the sequence of the blasting.

The bottom or draw cut, Fig. 4a, is the method usually used for small tunnels and mine openings where it is impractical to drill an effective wedge or pyramid.

Depth of Hole

The most economical depth of hole must be determined by trial in each individual case, because of the numerous variables influencing the result. Usually a depth of round from 60% to 75% of the width of the working will be found satisfactory.

Number of Holes per Round

Physical character of the rock is the most important factor in determining the number of holes per round. In general igneous rocks require more holes than sedimentary rocks.

Arrangement of Drill Holes in Shaft Sinking

Drill-hole location in sinking is governed by the fact that only one free face is exposed, and that to obtain maximum efficiency from the charge two faces are necessary. One or more cut holes are drilled at an angle to the free face, and blasted in advance of the other holes, which are placed to take advantage of the new face formed by the blast. The cut is usually drilled at the middle of the shaft section, though in large shafts they are at times placed at one end, retreating towards the opposite end in blasting, and firing each row of holes in series. This arrangement tends to throw the broken rock to one end of the shaft so that the opposite end may be speedily cleared for the machines to begin work while mucking is in progress.

Hand-drilled holes are usually shorter and more numerous than machine-drilled; they are placed with care to take advantage of the bedding planes, cracks and shape of face, not with especial regard to the symmetry of the arrangement. The cut is sometimes carried well in advance of the other holes, which recede towards the shaft ends in a series of benches.

Machine-drilled holes are placed and pointed in accordance with a system designed to give desired results even at increased powder consumption. A symmetrical arrangement facilitates the operation of the drills, and enables the maximum number of holes to be drilled from each set up of the shaft bar.

"V," center or wedge cut is most commonly used. It comprises a number of pairs of holes inclined towards each other from opposite sides of the short center line of the shaft, their bottoms being close together or preferably meeting. Figs. 5 and 6 show two forms of this cut. Holes in lines 1 comprise the cut and are blasted first. The other holes are blasted in sequence. Fig. 5 is a simple cut, while Fig. 6 is for a deep cut.

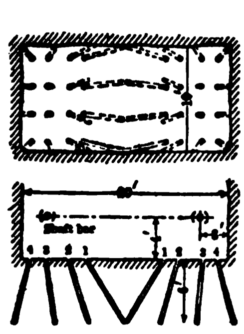

Fig. 5. "V," Center or Wedge Cut for Shaft Sinking

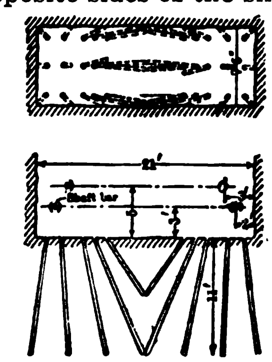

Fig. 6. Double-V or Wedge-Cut.

Pyramid cut is rarely used except in circular shafts. Figs. 7 and 8 show arrangement of this cut for round shaft and rectangular shaft, respectively.

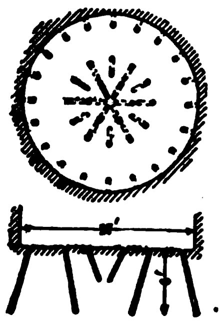

Fig. 7. Pyramid-Cut for Circular Shaft.

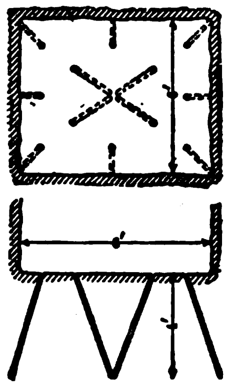

Fig. 8. Pyramid-Cut for Rectangular Shaft.

The bench or stope cut (Fig. 9) is sometimes used in tight ground. The cut is alternated from one side of the shaft to another. There are always two more or less free faces, thus increasing the efficiency of blasting. This cut also tends to project the broken rock towards the opposite end of the shaft, as do the wedge and center cuts, so there is less delay in setting up drills and damage to timbers and pumps.

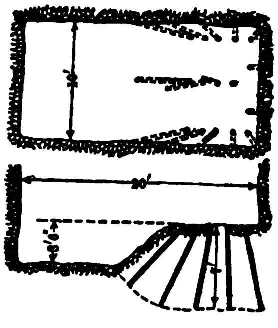

Fig. 9. Bench or Stope Cut.

Bottom cut (Fig. 10), similar to that used in tunnels, is sometimes useful for flat inclined shaft.

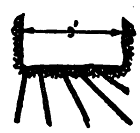

Fig. 10. Bottom-Cut for Flat Inclined Shaft.

COST OF HAND HAMMER DRILLING

Kind of work	Kind of rock	Men per drill	Hr per day	Wages, $	Diam of bit, in Start-ing	Fin-ishing	Depth of hole, ft	Ft per hr	Cost per ft, ¢
Railroad cut	Hard limestone........	3	10	....	....	1½	......	1.7	....
Open cut...	Mica schist............	3	..	....	1⅞	1¼	7.5	1.5	....
Open cut...	Mica schist............	3	10	2.00	1⅞	1¼	7.5	1.5	40.0
Side-hill cut	Gneiss..................	3	10	1.50	2	1¼–1½	6–16	1.41	40.3
Open cut...	Hard porphyry.........	3	..	....	....	....	20	0.6–0.8	80
Railroad cut	Very hard granite......	3	10	2.25	....	....	......	1.4	....
Railroad cut	Dark hornblende.......	3	10	2.25	1⅜	....	12	2.9	32.0
Railroad cut	Red granite............	3	10	2.25	1⅜	....	12	2.0	42.0
Railroad cut	Trap, diabase..........	3	10	2.25	1⅜	....	12	1.85	44.0
Block holes.	Red granite............	3	10	2.25	1⅜	....	av 1.25 0.5–4	1.04	74.0
Trench.....	Limestone..............	1	8	....	1¾	....	......	1.25	....
Trench.....	Shale....................	...	..	....	....	....	......	......	14.0
Open cut...	....	...	..	....	....	....	......	......	92.0
Tunnel.....	Gneiss, tough schist....	1	10	2.25	1⅜	....	2.0	0.35	....
Tunnel.....	Very hard mica schist..	2–3	..	....	1¼	....	1.67	1.00	....
Tunnel.....	Conglomerate, shale....	...	8	2.25	....	....	......	......	56.0
Tunnel.....	Tough sandstone........	1	8	....	0⅞	....	1.5	1.19	....
Tunnel.....	Very hard syenite, q'tzite	2	8	....	....	....	1.0	1.25	....
Mine.....	Augite diorite, firm red porphyry	2	10	2.00	1⅜	1¼	6.0	1.48	28.0
Mine.......	Chalcopyrite, limestone	2	10	1.35	1¼	....	......	1.0	....
Mine.......	Medium rock...........	1	..	....	....	....	2.5	0.5	....
Tunnel.....	Compact phonolite dike	1	8	3.50	1¼	....	2.5	1.0	....
Shaft.......	Compact phonolite dike	1	8	3.50	1¼	....	2.5	1.2	....

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CHICAGO PNEUMATIC TOOL CO.

Chicago Pneumatic Bldg.
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SALES AND SERVICE BRANCHES ALL OVER THE WORLD

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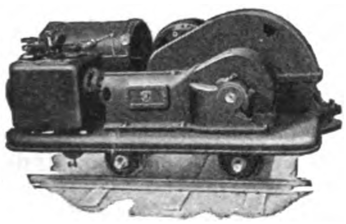
Air Compressors — Gas, Oil, Gasoline, Steam, Belt and Motor Driven; Vacuum Pumps and Gas Compressors; Receivers and Aftercoolers; Semi-Diesel Oil Engines; Gas and Steam Engines; Little Giant Air Hoists for Mine and Shop; Air and Electric Rock and Coal Drills; Boyer Pneumatic Hammers for Riveting, Chipping, etc.; Little Giant Electric Tools; Air Hose; Accessories.

Mine Car Compressors

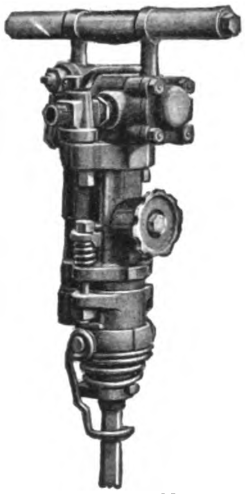
Operated by electric motor. Can be quickly moved to any section of the mine requiring air power. Saves time, expense and trouble by eliminating expensive systems of piping and line losses. Made in three sizes, 147, 218 and 314 cu. ft. per minute at 100 lb. pressure. Equipped with either D.C. or A.C. moisture-proof electric motor of any required standard voltage. Ask for Bulletin 501.



Mine Car Compressor. Truck wheels are adjustable to run on 18 to 56½ in. gauge track.

"Hummer" Air Hammer Drills

"Hummer" Hammer Rock Drills have independent rotation and are equipped with indestructible Ball Valves. Simplicity, sturdiness in construction, ease of operation, coupled with hard-hitting power, have been basic considerations in the development of HUMMER Drills. Can be operated by hand or mounted on drill column by using cradle mounting. Can be used for drifting, sinking and stoping. Made in two types, one for 'dry' and one for 'wet' operation. Ask for Bulletin 399.



"Hummer Air Hammer

"HUMMER" DRILLS AND ACCESSORIES

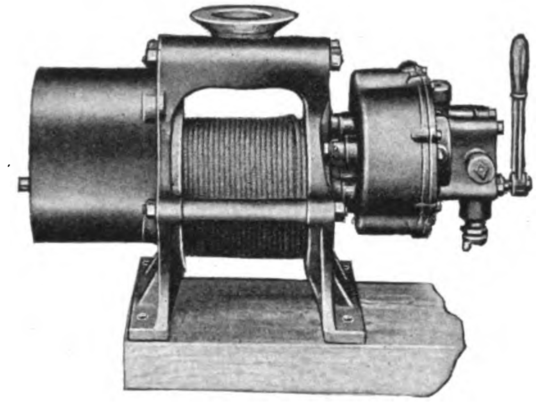
DESCRIPTIVE TABLE	A-86	A-86W
Cylinder diameter	2 1/16 in.	2 1/16 in.
Length of Stroke	3¼ in.	3¼ in.
Weight	48 lbs.	48 lbs.
Length overall	18¾ in.	18¾ in.
Size of Air Hose	¾ in.	¾ in.
Size of Water Hose	......	½ in.
Size of Hexagon Hollow Steel	⅞ in.	⅞ in.
Depth will drill easily	10 ft.	10 ft.
Code with equipment	Rezaba	Rhecomis

No. 5 Plug and Feather Drill

This drill is used in quarries for plug and feather work in splitting up large blocks. Holes ⅝ to ¾ inch in diameter and 3 to 6 inches deep are drilled. The design and material are proved, the machine having been in general use for years. Bulletin 172.

Little Giant Universal Hoist

For hoisting and lowering buckets, mine timbers, tools, etc.; pulling and "spotting" cars for slushing operations and other emergency work about the mine.

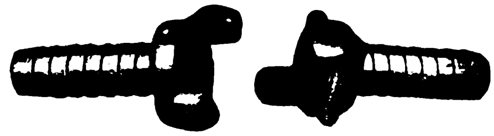


"Little Giant" Universal Hoist

Weighs 300 lbs. Will hoist 650 lbs. at a rope speed of 103 ft. per minute. Has a capacity of at least 1,000 lbs. Is rugged, simple and safe to operate, and can be either clamped to a drill column or bolted to a mine timber. Bulletin 621 gives full details.

Chicago Universal Couplings

Each side of coupling is a combination of male and female, allowing any size to be coupled to any other size. Made for male and female thread pipe, and for ⅜ to 1-inch hose.



Chicago Universal Couplings

Air Hose

The spring-like, braided construction of C-P Cord Air Hose makes it stronger than a cord automobile tire. Its exceptional strength, durability and wearing qualities, remove all need for wire winding; hence it is furnished **plain** only, in ½ and ¾" sizes, either 25 or 50 foot lengths. To users who want the **best** we urge the use of C-P Cord Air Hose.

C-P Cord Air Hose

Multiple Duck-Wrapped grade can be furnished either plain or wire wound. Made ⅜"—5 ply; ½"—5 ply; ½"—7 ply; and ¾"—7 ply sizes, each in 25 or 50 foot lengths. A high grade hose giving excellent service.

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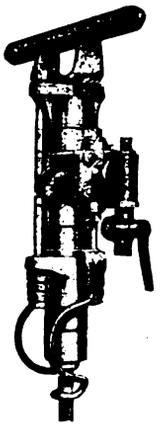
Manufacturers of

Rock Drilling Machines, Concrete and Pavement Cutters, Drill Columns, Steel, Etc.

Cochise Drills are distinctive for simplicity of construction, low up-keep cost and economy in power consumption—while the drilling speed easily exceeds any competitive drill of the same cylinder dimensions.



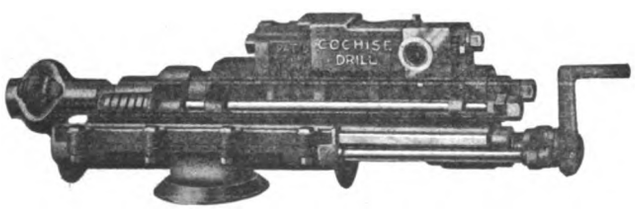
No. 36 Rock Hammer

Rock Hammers

Are made in three sizes. Each size is manufactured in both dry and wet types. They are equipped with automatic rotation, steel holders, hole cleaning device, etc. Can be used mounted or held by hand.

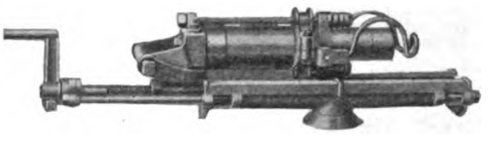
The No. 36 shown in picture weighs 45 lbs., consumes 52 cu. ft. of air at 85 lbs. pressure.

This drill has taken part in many contests and has never been outdrilled by drills in its class. It drills as fast as many of the larger machines, while consuming less than half the power.



Cochise Piston Drills

Are manufactured in sizes of 2½, 2¾ and 3¼ cylinder diameter. They are compact, strong and efficient.



Rock Hammer Mounted

This strong and compact mounting will withstand the strains rock drilling machinery is subjected to.

Cochise Stopers

We make these models in two sizes, 2⅛ and 2⅜ cylinder diameter.

They are equipped with our quick-acting valve, which enables them to strike hard and rapid blows, while the air consumption remains low.

They are convenient to operate; comparatively light and compact, with no lugs or other protruding projections that might get knocked off by careless handling.

Concrete Cutter

The Concrete Cutter is a non-rotating powerful hammer of the plugger type. It is most efficient in breaking up old foundations and cutting pavements.

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THE CLEVELAND ROCK DRILL CO.

General Offices and Plant

CLEVELAND, OHIO, U. S. A.

Branches in All Important Mining Centers

Products

Rock Drills—Augers, Drifters, Rotators and Stopers; Drill Columns and Mountings; Air Hose and Couplings; Air Valves; Drill Steel.

CLEVELAND No. 44 ROTATOR

This machine contributes greatly towards substantial reductions in drilling costs.

Increased drilling speed is accomplished by our exclusive patented Pocket-in-Head which acts as an air reservoir. It stores up air continually at line pressure, passing it on to the hammer piston at a higher pressure than is possible in any other rotator on the market. A "snappy" blow of the hammer results, and, consequently, increased drilling.

Cleveland No. 44 Rotator

Important parts are unbreakable, selected material being used throughout. Cylinder, grip handle, chuck housing, steel puller, etc., are expertly drop forged.

Oil is fed from a reservoir in the grip handle. If filled several times a shift with a good grade of light oil, drills will not stick.

The controlling valve on standard machines is an integral part — no external valve is needed. Mounted machines are equipped with an offset Spade handle and an external plug cock.

The Steel Puller is very simple. Stout springs, easily replaced if broken, absorb the shock.

Cleveland Valves—The valve is the heart of any drill. It must work freely and quickly. Equally, it must resist wear, as excessive wear results in quick depreciation of efficiency.

The Cleveland Tubular Valve has more wear resisting surface than that of any other rock drill made. This means long life, which is further assured by the use of specially selected, heat treated steel.

Type "Forty-Four" SD—Is the dry machine using standard sizes of hollow drill steel with 3¼" shanks. The machine is provided with a most efficient device for clearing the drill cuttings away with air.

Type "Forty-Four" SW—Is the wet machine using standard sizes of hollow drill steel with 3¼" shanks. Machine is equipped with a needle water valve on outside of the machine and a steel tube on the inside, running down through the packing nut and rubber packing which holds it solid and keeps water from entering the valve block or drill cylinder. This tube extends about 1½ inches into the shank end of the drill steel.

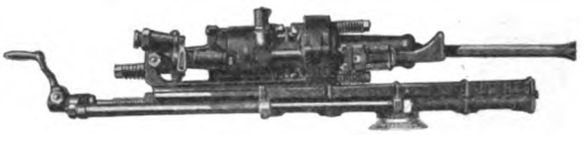
GENERAL SPECIFICATIONS

	No. 44SD	No. 44SW
LENGTH:		
Overall length without Steel Puller	18 in.	18 in.
Overall length outside of handle to outside of Steel Puller	20⅛ in.	20⅛ in.
Overall length Mounted Machine from back of feed screw handle to front of shell	45 in.	45 in.
WEIGHT:		
Rotator only	40 lbs.	41 lbs.
Shipping Weight	65 lbs.	66 lbs.

AIR HOSE:
Best results are obtained with hose of ¾" inside diameter.

DRILL STEEL:
Chuck for ⅞" Hex is standard unless otherwise specified; 1" Hex, ⅞" or 1" Quarter Octagon, or ⅞" or 1" Square can also be furnished if desired—all shanks are 3¼" long.

No. "Forty-Four" Mounting—Is light and rugged. The drill can be removed and used as a hand machine by loosening only two nuts. Ample locking devices prevent vibration from loosening the nuts. Water tubes can be removed without dismounting the drill.



The "Forty-Four" Mounting

No. 44-M MOUNTING

Weight—Mounting only	56 lbs.
Weight—of drill mounted	96 lbs.
Length of mounting overall	45 in.
Height	9½ in.
Distance from center of machine to top of mounting	2⅞ in.
Length of Feed Screw	40½ in.
Maximum travel of machine	30½ in.

CLEVELAND AUGER DRILL

A distinctive Cleveland product, built for use in soft shale, coal, soft iron ore, etc. Under actual test, it regularly drills about 25% more than its nearest competitor. It has a very rapid and durable spool valve, a powerful rotation at just the right speed for the work it does, and the usual Cleveland drop-forged construction. The regular chuck for this drill is the standard ⅞" Hex, for the 3¼" collared shank on twisted steel. Other shapes and sizes will be supplied when so ordered.

Air connection is ¾" and the drill weighs 35 pounds.

The best way to become acquainted with the Cleveland Auger Drill is to allow us to prove our claims for its efficiency by actual demonstration in your ground.

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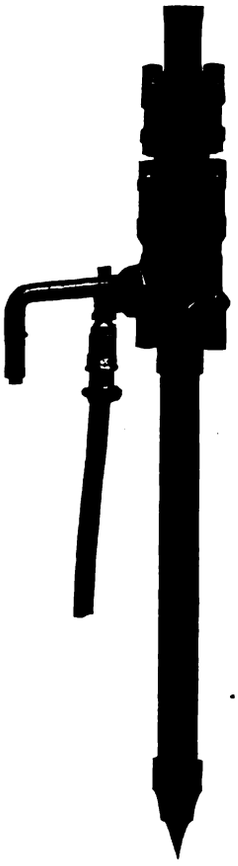
"NEW" CLEVELAND POCKET-IN-HEAD STOPERS

Are made in two sizes—the 2S, weighing 75 pounds, with piston diameter of 2 inches, and the 4S, weighing 100 pounds, with piston diameter of 2½ inches. The smaller machine is recommended for all but the very hardest rock, as it is easier to handle, on account of its light weight, and also because the weight of the blow which the piston hits is so much harder than that of any other hammer drill, that this increase, combined with a very high piston speed and practically 100 per cent air efficiency due to the "Pocket-in-Head", results in a drilling capacity very much in excess of that obtainable with any other similar machine.



2S "New" Cleveland Stoper

We guarantee that this 2S machine can do more work than any other machine you now have in operation.

What a "New Cleveland" will do in your mine under your conditions of rock—whether it is hard or easy to drill—can only be determined by a trial. A fair trial will convince you that the "New Cleveland" Stoper will increase your drilling per shift and decrease the expense by enough to pay for its initial cost many times over.

Hammer Head—Contains an air pocket which holds twice the air needed to supply the piston chamber. This is mainly responsible for the greatly increased drilling capacity of the 2S drills.

The pocket of air acts like the receiving tank of a compressor to a drill in operation. Without the air pocket the hose acts as a receiver, but a very poor one. By the use of the "Pocket-in-Head", line pressure is maintained on the piston during the entire stroke so that both the number of blows per minute and the force of each blow is increased—and these are the factors determining the speed of drilling.

Hammer Head

More work per shift, accomplished with less air, is the result of this feature of "New Cleveland" Type S Drills.

Valve and Block—Both are simple, carefully hardened and ground, and as the travel is short and the wearing surface large, long life and long continuance of the initial efficiency is assured. The piston goes completely through both valve and block, so even though extremely wet air at low pressure is supplied, which in some machines causes the piston to hit the valve on its rearward stroke and very often break it, no damage can be sustained in any way in type S machines.

There is also a dead air pocket at the rear end, which, acting as a cushion, reduces vibration, and positively starts the piston immediately on its forward stroke at the same instant the air is pouring into the cylinder from the "Pocket-in-Head". Because of the "Pocket-in-Head" and the very short, large air ports, the operating valve on type S Stopers is unusually fast, and as the speed of the valve controls the speed of the piston, we are able to get remarkable results—not only in cutting capacity but also in ease of rotation, no matter whether your rock is hard or soft.

Valve and Block

Lubrication—The hollow rocker handle, if supplied with a good light oil, will feed a small amount to the machine each time the throttle is opened insuring sufficient oiling of every moving part. This device must be filled at least once each shift.

Repairs—The "New Cleveland" Pocket-in-Head Stopers are of such design and made up of such carefully selected materials, that even if abused, they will stay at work longer than other drills of similar type. When repairs are necessary, however, the entire machine can be pulled apart by unscrewing four nuts. An unskilled laborer can make any repair very quickly.

Uses—The "New Cleveland" type S drill, because of its light weight and easy rotation, can be used for drifting as well as stoping, although originally designed as a stope drill only. If desired, hollow steel can be used with a hollow striking piece to allow the air to pass through the steel to blow out the cuttings.

Steel—We recommend the use of 1⅛" cruciform or 1" quarter octagon steel with type S Stopers.

Advantages

Large air ports.

Automatic oiling device.

Drop forged parts throughout.

One diameter reversible piston.

Unbreakable valve and valve block.

Greatest possible wearing surface on valve.

Pocket-in-Head reservoir, reducing air consumption.

INCREASED DRILLING.

REDUCED REPAIR COSTS.

REDUCED AIR CONSUMPTION.

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DRILL SUPPLIES

Cleveland "Veribest" Air Hose

Is made in one grade only, of such materials and to specifications best suited for Rock Drill Service.

"Veribest" Inner Tube is so compounded as to resist action of oil from the compressor and does away with trouble caused by pieces of rubber flaking off and getting into the ports of the drill.

"Veribest" Air Hose

The fabric is a high grade duck of selected weight, wound in proper number of plies to resist any usual working pressure and still leave the hose pliable.

Friction, or the property which sticks the tube, cover and different layers of fabric together in one unit, is exceptionally strong, and prevents blistering and the layers from coming apart in service.

"Veribest" Hose is carried in stock for immediate shipment in all sizes, plain, oval-wire wound or cotton-jacketed.

Prices and samples upon application.

Cleveland "Neverleak" Couplings

Are the quickest connection made to connect or disconnect hose to hose, hose to pipe or pipe to pipe. When used in place of unions, the ultimate saving is many times their first cost.

Cleveland "Neverleak" Coupling

A push and a turn makes an immediate air-tight connection; there are only three parts—male end, female end and gasket; no threads; no projections to catch when dragging hose around; they cannot become accidentally disconnected but can be connected without the use of a wrench and in the dark, if necessary.

"Neverleak" Couplings are made in ½", ¾" and 1" sizes, all of which are interchangeable.

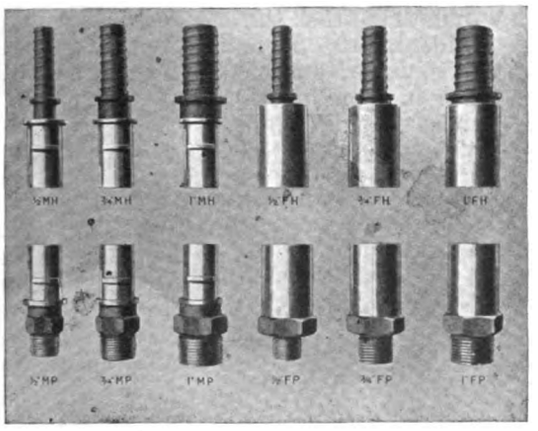


Chart of Sizes

IMPORTANT: Figures under Hose Ends refer to size of hose; under pipe ends to size of pipe threads. Both figures and symbol letters must be stated in your order.

Made in twelve sizes and types.

Any male end can be interchanged with any female end, whether hose or pipe.

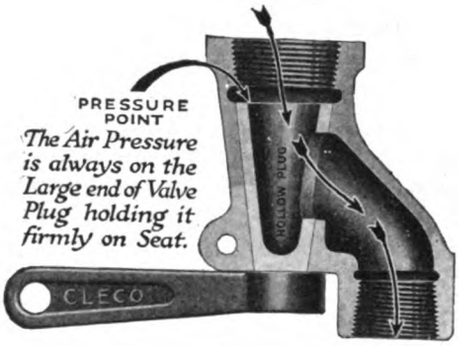
Any of the six ends on the left half of chart fit any of the six ends on the right half of chart.

Cleveland Pressure-Seated Air Valves

Are made "pressure tight" by the air itself which holds the valve plug firmly on its seat.

The air passes through the hollow plug into the hose line, but at no time does it touch the seat.

Cleco Valves never require packing, springs or renewal of valve seats, as do other makes. The saving of time in repacking is a big item.



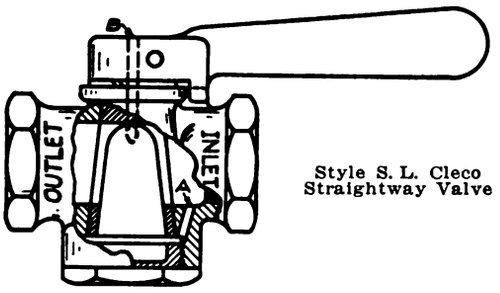
Cleco Pressure-Seated Air Valve

Style S. L. Cleco Straightway Valve

Is made in the following sizes: ¼", ⅜", ½", ¾", 1", 1¼", 1½" and 2" standard pipe thread inlets and outlets.

Inlets and outlets are the same size and in alignment; both are standard pipe thread.

The valve is adapted for either vertical or horizontal pipe to pipe connections or pipe to hose as desired.



Style S. L. Cleco Straightway Valve

The "pressure seated" feature is incorporated in this straightway valve.

The illustration above shows a bi-pass in the inlet end through which the air passes to the large end of the valve plug, where a constant pressure is maintained on the plug, holding it firmly on the seat.

"A" shows the bi-pass, "B" the waste port.

Engineering Service

We offer the services of our Cleco Sales Engineers without cost to air users who will make a careful analysis of air systems at your plant or mine and offer such recommendations of changes and additional equipment as appears necessary to bring your present air system up to date.

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INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Power Plant and Drilling Equipment

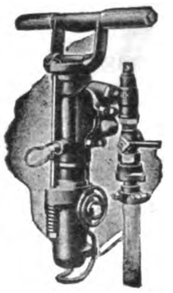
For Offices and Products See Pages 170, 171, 172, 458 and 459

Products

Rock Drills including mounted, hand hammer and stoper types; Rock Drill Mountings; Rock Drill Steel Sharpeners; Track Drills; Hose Couplings; Oil Furnaces; Pedestal Grinders and Shank and Bit Punches; Quarry Machinery; Rock Drill Steel and "Little Tugger" Hoists; Pneumatic Wood-boring Machinery. For other products see pages 170, 171, 172, 458 and 459.

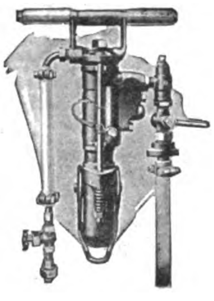
"Jackhamer"

The "Jackhamer" is the superior hand hammer type rock drill. The distinctive features are: All steel, dropped forge construction; automatic rotation; spring held front head; steel holder; automatic lubrication; efficient dust blowing device and "Butterfly" valve. The "Butterfly" valve is used on all types except the "DCR" and "DDR" which use a spool valve operating on the "Butterfly" principle.



BCR-430 "Jackhamer"

The "Jackhamer" has been developed in a large variety of sizes and types, each suited to a particular class of work as mentioned below. The last four types can be operated by either compressed air or steam. The last three can be furnished with (wet) or without (dry) water feeding device. This water feeding device is of the well known "Leyner" design in which water is passed through the backhead and water tube, then to the hollow drill steel where it is mixed with air under pressure. "Wet" machines allay the dust and remove rock particles from the cutting face of the drill bit, permitting each blow to do effective work. The cooling of the steel by the water has also been found beneficial in maintaining the temper of the bit.



BCRW-430 "Jackhamer"

Type "BAR-33" is for light drilling in soft or medium ground.

Type "BBR-13" and "BBR-230" are principally used with twisted auger in coal or soft iron ore.

Type "BCR-430" is designed to meet the greater majority of hand hammer drill work.

Type "DCR-13" is designed for shaft sinking in average rock or for work requiring a slightly heavier drill than the "BCR-430."

Type	Weight, Pounds	Length, Inches	Steels Hollow Hexagon, Inches	Air Hose Recommended, In.	Water Hose Recommended, In.
BAR-33	21½	15¼	⅞	½	..
BBR-13	37	17¾	⅞	¾	..
BCR-430	47	20	⅞	¾	..
BCRW-430	50	20	⅞	¾	½
DCR-13	56	22½	1	¾	..
DCRW-13	59	22½	1	¾	½
DDR-13	73	25	1	¾	..
DDRW-13	76	25	1	¾	½

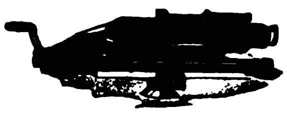
*When used with anvil block.

Type "DDR-13" is built for the heaviest and roughest hand hammer drill service.

Bulletin 4046 covers "Jackhamers".

"Jackhamer" Mountings

The "Jackhamer" Mounting is adapted for use either on the arm of a column, horizontal shaft bar or on a tripod.



BCR-430 "Jackhamer" in JC-10 Mounting

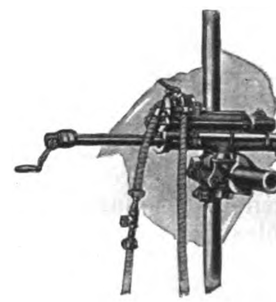
This is a thoroughly practical outfit for flat hole work, such as drifting, or tunnelling. The drill can, therefore, be used for a two fold purpose; mounted for drilling flat holes in the heading and unmounted for drilling down holes in the bench. Full details on request.

	JC-10 For "BCR"	JC-11 For "DCR"	JD-10 For "DDR"
Weight of Mounting	69 lbs.	70 lbs.	70 lbs.
Weight with Jackhamer complete	116 lbs.	126 lbs.	143 lbs.
Length	39 in.	39 in.	39 in.
Height	10¾ in.	10⅞ in.	11⅛ in.
Distance from bottom of cone to center of Jackhamer	8 in.	8 in.	8 in.
Feed—using ⅞" Hex. J. H. shanks	20 in.	20 in.	20 in.
Max. movement of sliding cone	19 in.	19 in.	19 in.

The standard 3" S. S. Column is suitable for use with the Jackhamer Mountings.

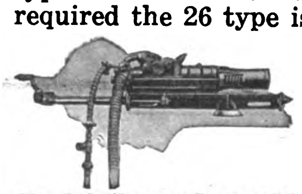
"Leyner-Ingersoll" Drifters

"Leyner-Ingersoll" Drifters have gained an enviable reputation for fast drilling with a minimum of up-keep cost and time lost for repairs. They are light in weight, easily handled and are the standard drills of many of the largest mines and rock drilling projects of the world.



No. 26 "Leyner-Ingersoll" Rock Drill

There are several different sizes manufactured especially to meet different requirements. Where pressures of 70 lbs. or above are available and for the usual drifting and tunnelling work, the 148, 248 or 448 types are recommended. Where a light drifter is required the 26 type is recommended.



No. 248 "Leyner-Ingersoll" Rock Drill

These hammer type drills embody a number of desirable features, such as, the "Butterfly" valve, automatic lubrication and rotation, water feed and chuck for all types of hollow steel.

Bulletin 4038 covers 148, 248 and 448 types. Bulletin 4120 covers the 26 type.

TYPE	No. 26	No. 18	No. 148	No. 248	No. 448
Weight, lbs.	95	150	148	156	156
Length, in.	40	47¾	48¾	47¾	47¾
Length of Feed, in.	20	24	24	24	24 and 30
Steels—Round Hollow, in.	..	1¼	1¼	1¼	1¼
Steels—Hexagon Hollow, in.	⅞	*1	*1	*1	*1
Air Hose Recommended, in.	¾	1	1	1	1
Water Hose Recommended, in.	½	½	½	½	½
Depth hole drilled, ft.	6 to 9	8 to 12	8 to 16	8 to 16	8 to 16

*When used with anvil block.

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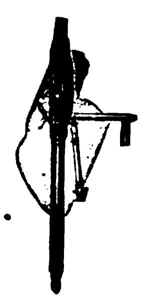
"Stopehamer"

The "Stopehamer" is the standard type of machine for the drilling of holes from 20 degrees above the horizontal to vertically upward. The general features of construction, applying to all types are: all steel construction, renewable anvil block bearing, single throttle control, "Heart-Beat" lubricators, extra long chuck and spring retained front-head.

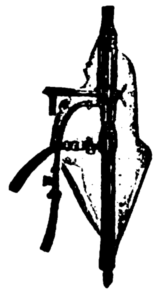


CC-11 "Stopehamer"

There are twenty patterns of "Stopehamer"; wet or dry; plain, extension, or reverse air-feed; light or medium weight; valve-controlled or valveless. Under the valve-controlled, are grouped the "BC" pattern which is equipped with "Butterfly" valve and is preferred where only medium pressures (about 70 lbs.) are available.

The "CA" and "CC" are valveless and are equipped with a differential piston and air exhaust relief valve. They are superior to any drill on the market for pressures higher than 70 lbs. These last two types are nearly identical except as to weight. The former fills the demand for an exceptionally light machine; the latter where the drilling conditions are more severe.

Bulletin 4311 covers the "BC" patterns and Bulletin 4336 covers the "CA" and "CC" patterns.



CCW-12 "Stopehamer"

	BC21	BCW21	BC22	BCW22	CC11	CCW11	CC12	CCW12	CC-21	CCW-21	CC-22	CCW-22
Bore of Hammer Cylinder	2″	2″	2″	2″	1⅝x2¾	1¾x2¾	1⅝x2¾	1⅝x2¾	1⅝x2¾	1⅝x2¾	1⅝x2¾	1⅝x2¾
Length of Stroke	4″	4″	4″	4″	3″	3″	3″	3″	4″	4″	4″	4″
Travel of Air Feed	22″	22″	22″	22″	22″	22″	22″	22″	22″	22″	22″	22″
Travel of Extension Pointer	...	...	...	...	...	...	...	...	...	...	...	...
Length of Drill (Feed Closed)	51¼″	52¾″	56½″	58″	51¼″	53″	56¼″	58″	55½″	57¼″	60½″	62¼″
Length of Drill (Feed Extended)	73¼″	74¾″	78½″	80″	73¼″	75″	78¼″	80″	77½″	79¼″	82½″	84¼″
Length of Drill (Feed Extended and pointer run out)	...	...	...	...	...	...	...	...	...	...	...	...
Diameter of Air Feed (Pressure 70 lbs. or over)	2⅛″	2⅛″	2⅛″	2⅛″	2¼″	2¼″	2¼″	2¼″	2⅜″	2⅜″	2⅜″	2⅜″
Diameter of Air Feed (Pressure under 70 lbs.)	2¼″	...	2¼″	2¼″	2⅜″	2⅜″	2⅜″	2⅜″	2⅜″	2⅜″	2⅜″	2⅜″
Size of Inlet	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″
Size of Hose	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″
Steels (No Collars required)	Solid ⅞″ Hex. 1″ Cruc.	Hollow 1″ Hex.	Solid ⅞″ Hex. 1″ Cruc	Hollow 1″ Hex.	Solid 1″ Hex. 1⅛″ Cruc.	Hollow 1″ Hex.	Solid 1″ Hex. 1¼″ Cruc.	Hollow 1″ Hex.	Solid 1″ Hex. 1¼″ Cruc.	Hollow 1″ Hex.	Solid 1″ Hex. 1⅛″ Cruc.	Hollow 1″ Hex.
Weight	75 lbs.	79 lbs.	89 lbs.	93 lbs.	78 lbs.	83 lbs.	93 lbs.	98 lbs.	90 lbs.	100 lbs.	100 lbs.	107 lbs.

Column and Tripod Mountings

The Company is prepared to furnish both single and double screw columns. They carry clamps with "Sergeant" saddles, fitting all types of drills or Universal column arm and clamps which permits a wider range of set-up with more ease. A complete round can usually be drilled with one column set-up when the Universal is used.

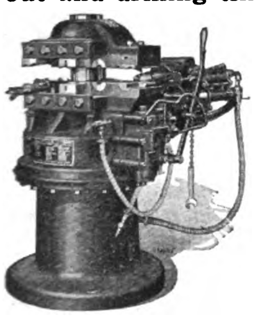
To suit special conditions the Company is prepared to furnish extra long columns, and special combination of column arms and clamps.

The Company also offers a complete line of tripods suitable for mounting all types of drills. All joints have cone surfaces, securing a powerful wedge effect under pressure of the adjusting bolts. The legs are telescopic and the weights adjustable.

Bulletin 9103 covers mountings.

"Leyner" Rock Drill Steel Sharpeners

"Leyner" Rock Drill Steel Sharpeners make and resharpen perfectly formed and accurately gauged bits of all sizes and types. Accurate gauging permits the employment of minimum gauge variation between successive steel. This means less rock to cut and drilling time saved.



"Leyner" No. 50 Sharpener

These sharpeners are simple, easily operated and the work absolutely uniform in quality. They shank as well as sharpen and insure shanks true to shape and size.

They are built in several sizes as follows:

The No. 50 Sharpener for forming and sharpening Carr, four and six point, "X," "Z," single and double chisel bits up to 3⅝″ gauge and all standard types and sizes of shanks on cruciform steel up to 2″ diameter and on heavier sections such as round, hexagon, octagon, etc., up to 1¾″ in diameter. It can be equipped to form both heads, pins, stanchions and in all about 200 different products.

Its capacity is, resharpening medium size steels 65-120 per hour. Forming new bits, 25-80 per hour. Bulletin 4322.

The No. 4 Sharpener for making and resharpening two, four and six point, "X," "Z," and single and double chisel bits up to 2⅛″ in diameter, on round, cruciform, hexagon, octagon, quarter octagon and the heavier sections of twist or branded steel of diameters not to exceed 1⅛″. (For heavier work the No. 50 Sharpener is recommended).

Its capacity is, resharpening minimum size steels 50-100 drill bits per hour. Forming new bits, 20-75 drills per hour. Bulletin 4322.

"Leyner" No. 33 Sharpener

The No. 33 Sharpener for making and resharpening four, five or six point, "X," "Z," and single or double chisel bits up to maximum of 2″ diameter, where the bits are of the standard 14 degrees taper. For Carr bits and other types of bits of a taper other than standard, the capacity is limited to bits not exceeding 1⅞″ finished diameter. These bits can be made on round, cruciform and on the lighter sections of twisted or branded steel not exceeding 1⅛″ in diameter; on hexagon or octagon steel up to 1″ diameter; and on square steel not exceeding ⅞″.

This Sharpener may also be employed when equipped with the various special shanking devices, for making collar shanks on ⅞″ hexagon steel or ¾″ square steel.

Its capacity is, resharpening ⅞″ steel—75 to 100 drill bits per hour. Forming new bits—50-75 drills per hour. Bulletin 4322.

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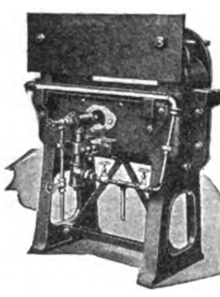
TYPE	No. 50	No. 4	No. 33
Weight, machine bare	2580	1750	960
Weight Steel Rest...	35 lbs.	35 lbs.	35 lbs.
Floor Space Occupied.	4'x4'	4'x4'	42"x42"
Height Overall......	53"	51"	48"
Maximum Size Stock Handled	2" round or Cruciform, 1⅞" Heavier Section	1⅛" Round or Cruciform, 1" Heavier Section	1⅛" Cruciform, 1" Heavier Section
Maximum Gauge Bit.	3⅝"	2⅛"	1⅞"
Capacity—Steel per Hour	50–150	50–100	50–100
Air Pressure Recommended	70–100	70–100	70–100
Hose or Piping Recommended	1¼"	1"	1"

Oil Furnaces

"Leyner" Oil Furnaces are built in two sizes, the No. 3 being especially adapted to drill steel sharpening plants employing one sharpener, and is capable of heating 1,000 to 1,500 pieces of steel per eight-hour shift and the No. 24 which will effectively heat 1,600 to 2,400 pieces of steel per eight-hour shift using only one side of the furnace and both sides may be used.

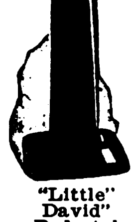


"Leyner" No. 24
Oil Furnace

These furnaces give a clear uniform heat which is at all times under the control of the operator and which is suitable for welding and tempering without special preparation; the smoke nuisance is abated and the absence of obnoxious gases is noted. No foundation is required and to put the furnace in operation it is only necessary to connect it to the oil and air supply, for the entire unit is compact and self-contained.

Bulletin 9120 covers the No. 3 and Bulletin 9031 the No. 24.

TYPE	No. 3	No. 24
Weight less tank—lbs.............	530	1070
Floor Space—feet	3x4	3x4
Heating Surface—inches	7½x10	6½x24
Capacity Drills per hour..........	150–120	200–300
Oil Consumption—gals. per hour...	2–4	2–4
Weight Oil Tank—lbs.............	150	150
Capacity—gals.	42	42



"Little" David" Pedestal Grinder

Pedestal Grinder

The "Little David" No. 8 Pedestal Grinder is a compressed air operated machine which is simple, self-contained and its light weight makes it entirely portable. It is principally used for squaring off and grinding true, rock drill steel shanks. It will save its cost in a comparatively short time by eliminating the drill breakage caused by improper shanks. Bulletin 4141.

TYPE	No. 8
Weight—lbs.	195
Floor Space—inches	17x18
Height—inches	44⅝
Diameter of Wheel—inches..........	8
Air Pressure used—lbs..............	70–100
Hose Recommended—inches	½

Shank and Bit Punch

The "Leyner" Shank and Bit Punch removes the uncertainty of the punching out of drill steel and insures uniformity of the work so that no drill steel will leave the shop in imperfect condition. It punches out either shanks or bits on all sizes of steel and eliminates the costly experience of broken off pins in the drill steel hole.

They are built in the Pedestal Pattern (in which case it is a distinct machine) and in the Attached-to-Sharpener Pattern (in which case it is an auxiliary part of the rock drill steel sharpening machine itself).

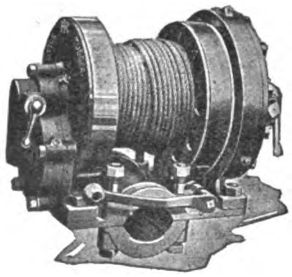
Leyner "IRLP" Shank and Bit Punch	Pedestal Pattern	Attached-to-Sharpener Pattern
Weight, Pounds..................	610	227
Floor Space, Inches..............	30x54	.....
Height, Inches..................	47	.....
Maximum Range of Punching, Inches..........	6	6
Air Pressure Used, Pounds Gauge..........	60-100	60-100
Hose Recommended, Inches..........	¾	¾

Ingersoll-Rand Swedish Drill Steel

A full line of special Ingersoll-Rand Swedish drill steel is carried for different types of drills, whether of piston or hammer type and quick deliveries can be made on demand. This steel may be had with or without shanks or bits and the bits may be of any style desired. Steel of the very best quality is used as the drilling capacity of a machine depends very largely upon its steels. It is, therefore, important that it be the best and carefully sharpened and tempered. The very best results may be expected from I-R Rock Drill Steel. Bulletin 9025.

"Little Tugger" Hoists

The "Little Tugger" Hoists are small, compact, portable—yet powerful—drum hoists. They can be clamped to a column or pipe or bolted to a timber in a few minutes time.



"Little Tugger" Hoist

As might be supposed, they have "a thousand and one" uses—hoisting, hauling, skidding, etc., in mines, mills, quarries and every other industry.

"Little Tugger" Hoists are built in several sizes (to develop from 2½ to 8½ H.P. from 60 to 80 pounds gauge pressure) and in single and double-drum patterns.

A very important use of the double-drum (No. 6-H) "Little Tugger" is for "slushing" (shoveling and loading rock and ore) both underground and on the surface. Bulletin 4333.

Type	No. 1-H & 1-HS	No. 11-H & 11-HS	No. 5-H & 5-HS	No. 6-H	
Weight less Cable, lbs...	285	358	475	640	
Width, inches..........	21¼	31¼	28½	29¼	
Length, inches..........	16½	21½	18	27½	
Height, inches..........	20⅛	23	18	20⅝	
				Haulage Drum	Tail Rope Drum
Size of Drum, Rope Space, Diameter, inches......	6	7	8	8	11
Size of Drum, between Flanges—Length, inches.	7	17	9	3½	3½
Depth of Flanges, inches..	3	5	3⅝	14⅝	16¼
Rope Capacity, feet......	¼-in.—700	⅞-in.—300	⅝-in.—645	⅝-in.—200	⅝-in.—250
Hoisting Capacity at 80 lbs. Pressure, lbs.....	85 ft. per min. 1000	85 ft. per min. 600	100 ft. per min. 1500	*110 ft. per min. 1500	*140 ft. per min. 1190
Horse Power...........	2½	2½	5	5 to 8.5	
Hose Recommended, inches	¾	¾	1¼	1¼	

*At 65 Pounds Air Pressure.

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SULLIVAN MACHINERY COMPANY

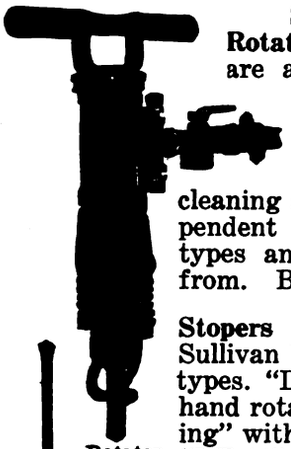
129 South Michigan Ave., CHICAGO, ILL., U.S.A.

DOMESTIC SALES OFFICES
Birmingham, Boston, Butte, Claremont, N. H., Cleveland, Dallas, Denver, Duluth, El Paso, Huntington, W. Va., Joplin, Knoxville, New York, Pittsburgh, St. Louis, Salt Lake, San Francisco, Spokane.

FOREIGN SALES OFFICES
Algiers, Brussels, Calcutta, Christiania, Durban, Natal, Havana, Lima, London, Madrid, Mexico City, Paris, San Juan, Santiago, Shanghai, Sydney, N.S.W., Tokyo, Toronto, Tunis, Turin, Vancouver.

Sullivan Products

Air Compressors; Air Lift Pumps; Diamond Drills; All-Hammer Drill Sharpeners; Drill Steel Furnaces; Forge Hammers; Ironclad Coal Cutters; Rock and Hammer Drills; Quarrying Machinery; Contractors for Diamond Core Drilling; Turbinair Portable Hoists.



Rotator

Sullivan Hammer Drills

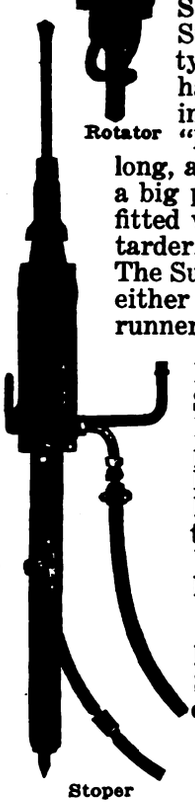
Rotators

are all around, one-man drilling machines; weight 38 lbs.; capacity, holes 6 to 14 feet deep. Automatic piston type rotation, steel retainer, hole-cleaning air jet and differential, independent valve are features. Seven types and two mountings to select from. Bulletin 70-WMC.

Stopers

Sullivan Valveless Stopers are of two types. "DT-44," "Lightweight," with hand rotation, and "DT-421," "Rotating" with automatic rotation of steel. "DT-44" weighs 63 lbs. and is 48 in. long, a drill for high stopes. "DT-421" is a big powerful drill, weighs 97 lbs. and is fitted with air controlled feed brake or retarder.

The Sullivan Water Attachment, used with either type, wets the dust, doesn't wet the runner. Bulletin 70-MMC.



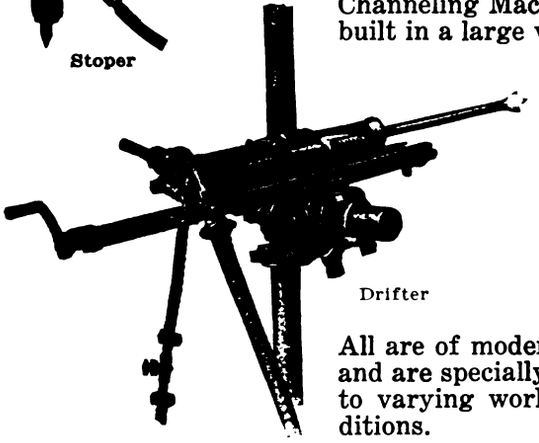
Stoper

Drifters

Sullivan water-jet mounted Hammer-Drifters, "DX-61" are big, fast, powerful drills, for tunneling and heavier mine work. They are valveless, have a big cylinder, fast rotation, best in any ground, hard or soft. Weight, "DX-61," 164 lbs; 14 ft. holes, 1¼ in. round, hollow steel. Bulletin 70-SMC.

For Quarry Work

Sullivan Plug Drills, Sullivan Gadders, Tripods, Quarry Bars and Stone Channeling Machines are built in a large variety.



Drifter

All are of modern design and are specially adapted to varying working conditions.

Sullivan Rock Drills

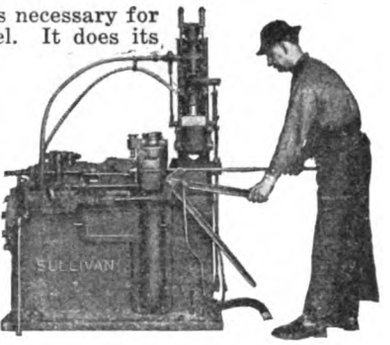
For heavy work in road metal quarries, on high ledges or on quarry bars Sullivan "Hyspeed" auxiliary valve drills are suggested. For deep holes downward or flat toe holes, their pulling power, force of blow and rugged strength render "Hyspeed" drills very effective. Supplied in air or steam types in sizes from 2¾ to 4¼ in. with hollow piston feature, if desired. Bulletin 70-QMC.

Sullivan Clay Spaders and Sullivan Pick Hammers are at your service, too. Bulletins 70-X and 70-V.

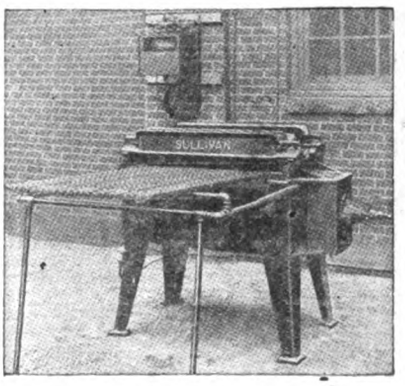
The best drill and the most costly drill steel won't raise your tonnage or lower your costs as they should, if your drill bits are not right.

Sullivan Rock Drill

The Sullivan Sharpener embodies all the elements necessary for proper care of drill steel. It does its work, both upsetting and swaging, by gradual hammering. It does not require injurious temperatures. Class "A" weighs 4,000 lbs. Size 5x2½x6 ft. (high). A smaller size, Class "B", weighs 1,500 lbs., and is suitable for bits up to 2½ in. gauge. Recommended for Hammer Drill Steel. Bulletin 72-EMC.



Drill Sharpener



Drill Steel Heating Furnace

Drill Steel Furnaces

Heat your drill steel safely, uniformly, conveniently, in the Sullivan oil or gas furnace; weighs 2500 lbs., holds 16 to 25 steels on each side. Economical of fuel. Bulletin 74-MC.

Sullivan Column Hoist

The Sullivan Turbinair Hoist weighs 285 lbs., has a capacity of 500 ft. 5/16 in. rope, and lifts 2000 lbs. vertically on 75 lbs. air; H. P. 6½. Turbinair motor is quiet and efficient, providing high torque in starting. Control is by friction clutch and hand brake. A double drum hoist for slushing is also built.

Bulletin 76-AMC.

"Turbinair" Hoist

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C. C. BRADLEY & SON, Inc.

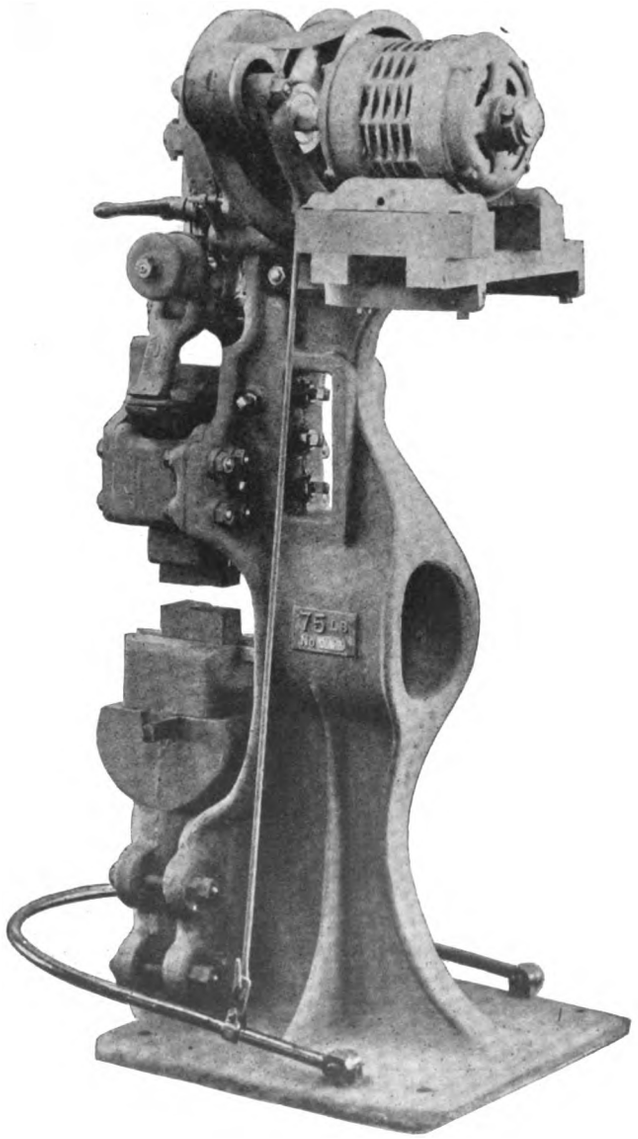
SYRACUSE, NEW YORK

Bradley Hammers

Products

The Bradley Cushioned Helve Hammer.
The Bradley Upright Strap Hammer.
The Bradley Upright Helve Hammer.
The Bradley Compact Hammer.
Equipped for either belt or motor drive.
Forges for Hard Coal or Coke.

The Bradley Hammer has been manufactured since 1872, and many of the first hammers made are still in active service.



Compact Hammer With Motor Drive

The Bradley Compact Hammer requires less floor space than our other types, runs at higher speed and has fewer parts, all of which are in plain view of the operator. There is not a steel spring, or a frail, delicate part about the hammer.

Mine Work That Can Be Done

The Bradley Hammer is practically a complete forge shop in itself. It is only a question of supplying the necessary dies and any tools required about the mine can be made.

With a Bradley Hammer the mine shop can forge all your wrenches; draw bars; brake rods; clevises; coupling pins and links; bumpers; miners' picks; mining machine bits; hooks; chisels, and, in fact, every style or shape of forging required in the operation and maintenance of the mine equipment.

The Bradley Hammer has its anvil and block separate and distinct from the main form, and is so formed and connected to the form that it may be quickly and accurately adjusted or shifted to bring the dies in perfect alignment.

Anvil blocks and anvils are regularly made of a special mixture of cast iron, but in special cases, cast steel can be used.

The Bradley Hammer is provided with a slip sleeve or grip, by which the opening between the dies may be regulated to admit large or small work.

The motion is imparted to the hammer by means of a foot treadle operating an idle pulley against the down moving side of a constant running loose belt. A slight pressure on the treadle will at once start the hammer, and varying this pressure regulates the force and rapidity of the blows. The treadle extends around the side and front of the hammer, so that the operator may stand on either side or in front.

When the hammer is at rest, the dies are always open.

Sizes

Bradley Hammers are made in sizes of 15, 30, 50, 75, 100, 125, 150, 200, 300 and 500 lbs., for iron ranging in size from ⅜ inch to 5 inches. Weights range from 800 lbs. to 13,200 lbs., according to the size of the hammer.

One Bradley Hammer has been in operation 12 years making picks, with a chisel and a pick end. The average output, per nine-hour day, for one hammer man and one helper, is 400 picks, or 800 ends.

Engineering Service

Let us know what you want to do, giving sizes and kind of materials used. This will enable us to suggest the type and size of Bradley Hammer best suited to your work.

Write for Bulletins and Prices.

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THE B. F. GOODRICH RUBBER CO.

AKRON, OHIO

Branches		Branches
Atlanta, Ga.		Detroit, Mich.
Baltimore, Md.		Kansas City, Mo.
Boston, Mass.		Los Angeles, Cal.
Buffalo, N. Y.		New York, N. Y.
Chicago, Ill.		Philadelphia, Pa.
Dallas, Texas		San Francisco, Cal.
Denver, Colo.		Seattle, Wash.

TRADE MARK

THE INTERNATIONAL B. F. GOODRICH CORP.

London Capetown Singapore

Air Drill Hose

Mechanical Rubber Goods of Every Description

For Transmission Belts, see pages 206 and 207; for Conveyor and Elevator Belts, see pages 662 to 666; for Steam Hose and Packing, see pages 190 and 191; for Fire Protection and Water Hose and Couplings, see pages 794 and 795.

Air Drill Hose

Air Drill Hose presents problems that are often very difficult of solution. In choosing hose for your conditions these problems should be kept constantly in mind, and the ability of the hose you buy to meet them carefully analyzed.

The first, and often most serious problem, is the compounding of the tube to resist the injurious action of oil which may work past the compressor, or which may be injected into the air line to lubricate the drill.

The second is that of making the hose strong enough to stand the pressures common in this service, without impairing its flexibility and lightness of weight.

The third is the designing of a hose that shall be as nearly kink-proof as possible.

The fourth is the protection of the hose from severe external abrasion, caused by dragging it over sharp loose rock, etc. In addition it must in many cases, resist the impact of rocks which fall upon it, often from a considerable height. Wire winding, while generally efficient against abrasion, is worse than useless against this impact, as it is easily bent out of shape, and can never be bent back to as perfect a condition. This bending generally causes constriction of the hose, and loss of pressure.

Goodrich Brand

Goodrich Air Drill Hose has been designed with these problems in mind, and has, we believe, successfully solved them. Its record in many a mine and quarry is proof of that fact. It has the oil resisting tube so necessary in this type of hose, a strong, flexible seamless fabric that will not kink and will resist the highest pressures, and a cover so tough and heavy that abrasion and falling rocks can make no impression on it. Its first cost is higher, but like all quality products its final cost is far below that of standard constructions, and the satisfaction and freedom from trouble gained

by its use makes it the final choice of those who appreciate the best.

Wire winding s unnecessary with GOOODRICH Brand, and should not be specified.

Quarry Brand

For those who prefer the standard wrapped duck type of hose Quarry is our recommendation. It has an oil resisting tube, sufficient plies of stout fabric to resist any working pressure, and as an additional protection against abrasion, a ply of heavy duck laid over the rubber cover. Furnished wire wound when desired.

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NEW YORK BELTING & PACKING CO.

New York.....91-93 Chambers St.
Boston.....65 Pearl St.
Chicago.....124-126 West Lake St.
Philadelphia.....821-823 Arch St.
Pittsburgh.....420 First Ave.

Denver.....1635 Seventeenth St.
St. Louis.....218-220 Chestnut St.
San Francisco.....519 Mission St.
Salt Lake City.....313 Felt Bldg.
El Paso.....Martin Bldg.

Indestructible Air Drill Hose

For Other Products See Page 667

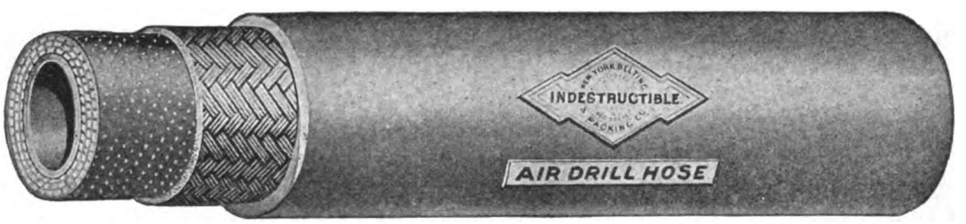
Indestructible Air Drill Hose is built to stand the rough usage of mining work. Years of service under the most severe conditions have proved this hose to be the most reliable for all drilling operations.

Points of Superiority

1. Stands the highest pressure. The strength of Indestructible Hose is more than sufficient to hold any normal working pressure with a wide margin of safety.
2. Resistance to external injury is a marked feature of Indestructible Hose. The thick rubber cover made of a tough, resilient stock is not easily damaged by dragging the hose over rough places or around sharp corners. In the majority of cases wire winding or other protection is unnecessary.
3. The rubber tube is compounded to withstand the effects of oil, which gets into your air lines. The tube can be depended upon to retain its adhesion to the fabric.
4. The comparatively light weight of Indestructible Hose means ease in handling. The flexibility and non-kink features are readily appreciated when working in close quarters.

Structural Features

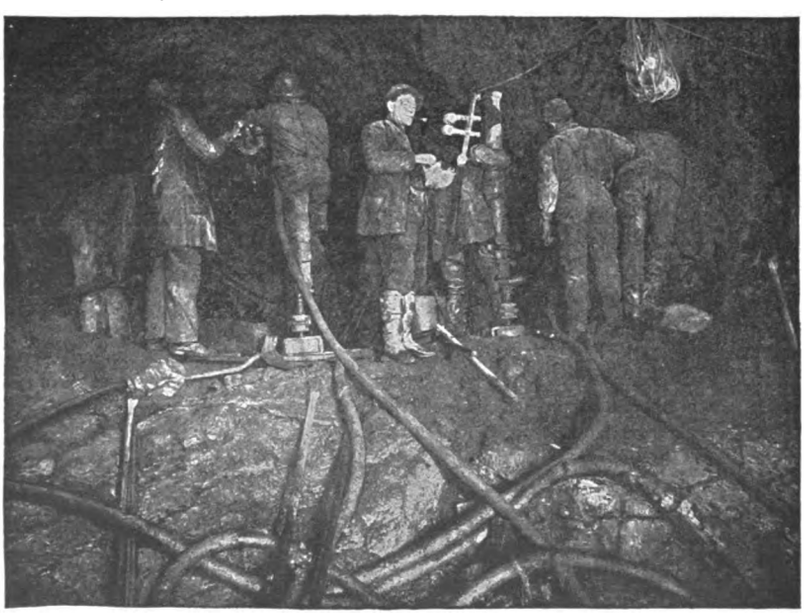
The illustration below shows how Indestructible Hose is designed. Here is construction you can see is good. The combination of wrapped duck and braided jacket gives the necessary strength and flexibility. Rubber stocks of the highest quality are used throughout.



When ordering, specify diameter of hose and working pressure for which hose is desired.

Hose for Other Uses

We make Hose for all classes of service, such as steam, water, etc., built on the same principle as Indestructible Air Drill Hose.



Indestructible Air Drill Hose In Mining Operation.

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UNITED STATES RUBBER COMPANY

1790 Broadway, NEW YORK

Branches in Every Industrial Center

PACKINGS AND HOSE

Products

Packing—Sheet, Spiral, Canvas and Flax; Pump Valves; Hose—Air, Drill, Steam and Fire, Water and Oxy-acetylene.

There is a tested type of United States Packing to meet practically every mechanical need. Our engineers are at your service to aid you in determining the most suitable style or brand to meet each of your requirements.

"U. S." Rainbow Sheet Packing

The original red sheet—for packing flanges or joints against steam, air, hot or cold water. Recommended for all saturated steam pressures up to 150 pounds, all hydraulic conditions, and high pressure, hot and cold water flange joints, cylinder heads, etc.

"U. S." Vanda Compressed Asbestos Fibre Sheet Packing

For packing flanges or joints against superheated or saturated steam, air, acids, oils, or alkaline conditions, etc.

"U. S." High Pressure Diagonal Packing

For packing rods and outside packed plungers against steam, air, hot and cold water. Especially adapted for high duty mine pumps, hoisting engines, etc.

"U. S." Rain-Besto High Pressure Spiral Packing

For packing rods against high pressure steam and air. Recommended for all high pressure steam conditions on rods and valve stems of all types of engines, air compressors, steam turbines, pumps, and air end of high pressure air compressors. Will also be found a very desirable packing for steam expansion joints.

"U. S." Peerless Cross Expansion Packing

For packing rods or plungers against medium pressure steam, hot or cold water. A very desirable type of packing for worn rods or plungers and those running out of alignment.

"U. S." Peerless Special Canvas Pump Packing

For packing the pistons of inside packed pumps against hot or cold water.

"U. S" Peerless Brand Flax Packing

For packing rods and plungers of outside packed pumps against hydraulic pressure.

Usco Rubber Pump Valves

Made in a variety of compounds, each adapted for a particular condition.

We have selected and described on this page the types of hose in greatest demand by the mining industry. We manufacture, however, a full line of hose for every purpose including oxygen and acetylene hose, suction hose and water hose. Our entire line is described and illustrated in our catalogue which we will be glad to mail upon request.

"U. S." 48-10 Air Hose

The fabric in our "U. S." 48-10 Pneumatic Tool Hose is of "herring-bone" construction, designed to produce the greatest possible flexibility along with the necessary strength to withstand high pressure.

The inner tube, made of special quality rubber, is almost twice as thick as the inner tube of the average air hose, and shows exceptional resistance to oil.

The outside cover of "U. S." 48-10 is made of an extra thick high grade material calculated to withstand continual abrasion. The high resisting properties of this cover make it unnecessary to use wire wrapping, thus eliminating the disadvantage of heavy non-flexible wire wound hose.

"U. S." Leyner Drill Hose

Our "U. S." Leyner Drill Hose, for conducting water to a Leyner Mining Drill is meeting with the same success as our 48-10 Air Hose. Made any size, but ½" double cord is most used.

"U. S." Steam Hose

To resist high pressure combined with high temperatures and rough handling, all possible experience and manufacturing knowledge are drawn upon to the utmost in the construction of our various brands of Steam Hose. We can serve our customers best if we are given full and complete information as to the exact operating conditions, so that we can recommend the proper type and ply of steam hose to use.

Very frequently steam hose is ruined by improper coupling. To reduce this risk to the minimum we recommend the use of our Samson High Pressure Couplings.

"U. S." Fire Hose

For fire prevention in the mines there is no better hose than the complete line that we manufacture including the famous "U. S." Mastiff and "U. S." Matchless brands which have been used for Industrial Fire Prevention for years.

A wide range of choice is possible as regards price and quality. "U. S." Fire Hose is made in Linen, Cotton Rubber Lined and Rubber Covered and will be found durable and economical.

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DIXON VALVE & COUPLING CO.

Eighth and Locust Streets, PHILADELPHIA, U. S. A.

NEW YORK PITTSBURGH

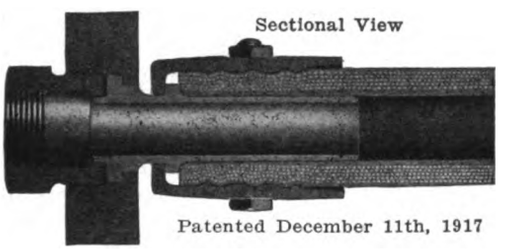
Manufacturers of

"Boss" and "Dixon" Couplings, Valves and Special Hose Fittings For All Makes of Drills

"Boss" Couplings

For Rock Drills using either steam or air, the "BOSS" is especially popular because of its big safety factor in all respects and its ruggedness.

The "BOSS" is massive in design; it has fine common sense features of construction. In machining and finish it shows the work of craftsmen—every coupling a clean, accurate expert product.



The sectional view shows a "BOSS" coupling attached to hose. The end of the clamp stops within a quarter of an inch or so from the end of the stem. When the bolts of the clamp are tightened there is no possibility that the end of the clamp can effect a shearing action on the tube of the hose. We further safeguard against such trouble by recessing the end of the clamp. This clamp cannot pinch the tube between itself and the end of the stem. If the hose happens to be sharply bent at the coupling, instead of being held rigidly in place at the stem end, the recessing provides a certain freedom of movement so that the tube is not cut or broken through.

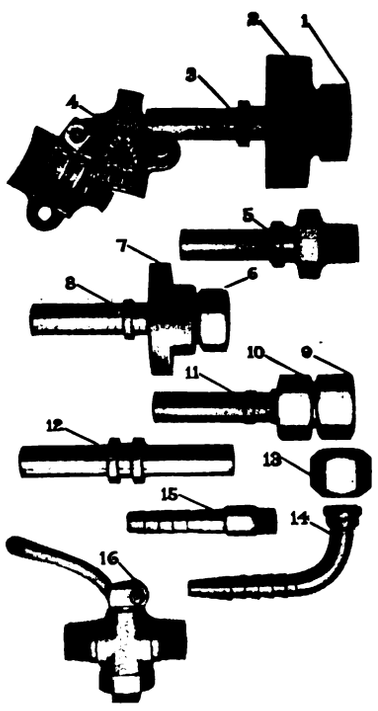
Special Drill Couplings

We solicit your inquiries for special couplings and parts. The knowledge we have gained in making these couplings for our customers, from steel castings and steel bar, leads us to believe that we can serve you acceptably.

"BOSS" Valves

A very efficient throttle valve. It is mechanically correct and will withstand the roughest kind of service. It is made from drop forgings by highly skilled workmen. Though extremely sensitive, the "BOSS" will not open or close due to vibration of the drill.

PARTS AND SIZES OF "BOSS" AND "DIXON" COUPLINGS AND VALVES



"BOSS" COUPLINGS—Sizes ½" to 3"—(Parts 1-2-3-4)
Part 1, Spud — Part 3, Stem
Part 2, Nut — Part 4, Clamp

"BOSS" MALE COUPLING—Sizes ½" to 2"—(Parts 5-4)
Part 5, Stem — Part 4, Clamp

"BOSS" JACKHAMMER COUPLING—Sizes ½" and ¾"—(Parts 6-7-8-4)
Part 6, Spud — Part 8, Stem
Part 7, Nut — Part 4, Clamp

"BOSS" LEYNER COUPLING—Sizes ½" and ¾"—(Parts 9-10-11-4)
Part 9, Spud — Part 11, Stem
Part 10, Nut — Part 4, Clamp

"BOSS" MENDER—Sizes ½" to 3"—(Parts 12-4)
Part 12, Stem — Part 4, Clamps (2)

WATER TANK CONNECTION—Size ½"—(Parts 13-14-15-20)
Part 13, Hose Coupling Nut — Part 15, Steel Nipple
Part 14, Bent Hose Stem — Part 20, Clamp

"BOSS" THROTTLE VALVES—Sizes ½", ¾", and 1"—(Part 16)

"DIXON" LEYNER DRILL COUPLING—Size 1"—(Parts 17-18-19-20)
Part 17, Spud — Part 19, Stem
Part 18, Nut — Part 20, Clamp

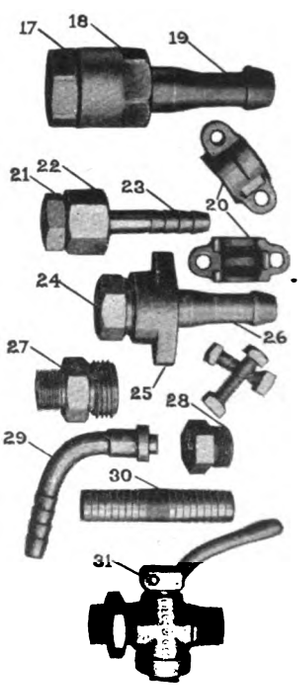
"DIXON" LEYNER DRILL COUPLING—Sizes ½" and ¾"—(Parts 21-22-23-20)
Part 21, Spud — Part 23, Stem
Part 22, Nut — Part 20, Clamp

"DIXON" JACKHAMMER COUPLING—Sizes ½" and ¾"—(Parts 24-25-26-20)
Part 24, Spud I. P. Female — Part 26, Stem
Part 25, Nut — Part 27, Spud I. P. Male

WATER HOSE CONNECTION—(Parts 28-29-15-20)
Part 28, Nut — Part 15, Steel Nipple
Part 29, Bent Hose Stem — Part 20, Clamp

"DIXON" HOSE MENDER—(Parts 30-20)
Part 30, Stem — Part 20, Clamps (2)

"BOSS" JACKHAMMER THROTTLE VALVES—Sizes ½" and ¾"—(Part 31)



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KNOX MANUFACTURING CO.

INCORPORATED

811-821 Cherry Street, PHILADELPHIA, PA.

High Pressure Couplings, Throttle Valves and Oilers, Hose Clamps

Products

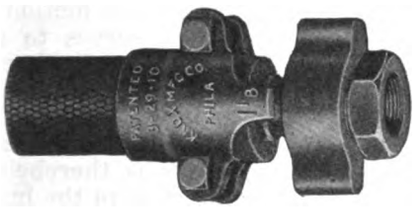
High Pressure Couplings; Throttle Valves and Oilers; Hose Clamps; Malleable Nipples.

Knox Hose Couplings

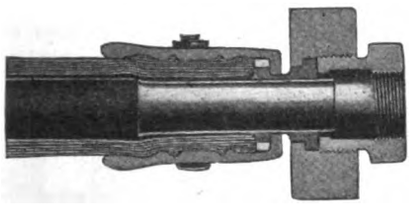
The Knox Coupling is especially adapted for steam and air drill service and is made to withstand severe usage.

It is constructed on the best mechanical prinples; the clamp exerts an equal pressure its entire circumference and extends over collar on the stem, thereby insuring safety under all pressures.

The length of the clamp distributes the bend of the hose and prevents it from breaking sharply over end of stem.



Coupling Complete



Sectional View

List price each, complete with spuds

½ inch	$1.25	1 inch	$2.00	2 inch	$ 5.00
⅝ inch	1.70	1¼ inch	3.00	2½ inch	8.75
¾ inch	2.00	1½ inch	3.50	3 inch	11.25

Spuds connecting with pipe or drills are standard iron pipe thread.

Five-eighth inch regularly furnished with spud, ½ or ¾ inch thread. At a small additional cost, coupling can be furnished with spuds of following sizes:

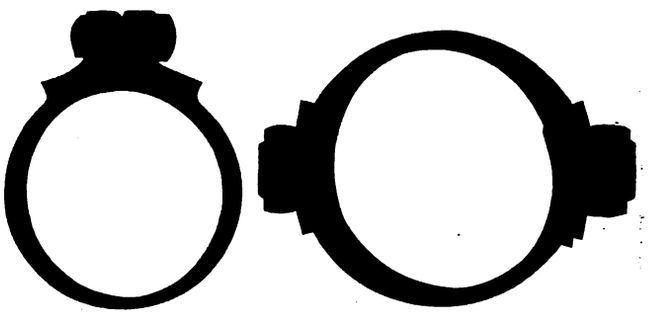
¾ inch with 1 or 1¼ inch thread
1 inch with 1¼ inch thread
1¼ inch with 1½ inch thread

We furnish with couplings, without additional charge, the following special sizes of clamps to accommodate hose with exceptionally heavy wall or with cotton woven cover.

½ inch with ⅝ inch clamps
⅝ inch with ¾ inch clamps
¾ inch with ⅞ inch clamps
1 inch with 1⅛ inch clamps
2 inch with 2⅛ inch clamps

"Rex" Malleable Hose Clamps

These clamps are exceptionally strong and pliable; they will not stretch under tension, neither will the tongue curl up; they are therefore superior to brass clamps, and also cheaper.



Single Bolt Double Bolt

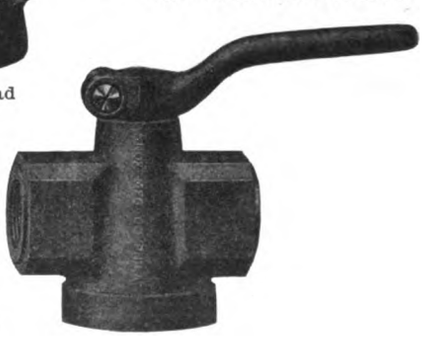
"Knox" Throttle Valves

This valve is built for high-pressure service, the body being constructed of malleable iron and strongly reinforced where the strain is greatest as shown in the illustration.

The "Knox" Valve has no weak points, automatically adjusts itself to wear, always works free and easy and will not close or jar open by vibration.

Male Thread

The Female Thread is shown in the illustration. The construction is exactly the same as the Male Thread, except that the ends are female.



Female Thread

The Female is used by inserting iron pipe nipples, which receive all the jar and vibration, and which, in the event of breakage, can be readily removed and replaced without injury to valve.

List Each, Male Type		List Each, Female Type	
½ inch	$ 2.50	¾ inch	$3.75
¾ inch	3.75	1 inch	4.40
1 inch	4.40		

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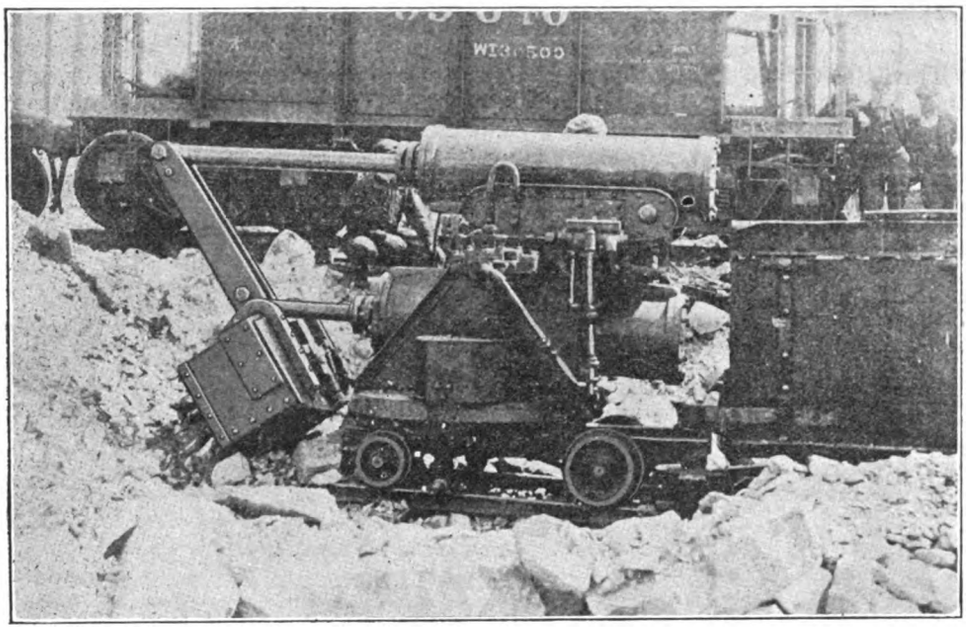
THE COLE-GOUDIE SHOVEL CO.

IRONWOOD, MICH.

"Pneumatic Shovels"

General Description

The Cole-Goudie Shovel is a small, one man pneumatic shovel designed primarily for use in underground operation, where head room and turning space are necessarily limited. However this does not detract from its adaptability for use in general quarrying work for which its low cost, flexibility and minimum upkeep make it extremely desirable.



Starting

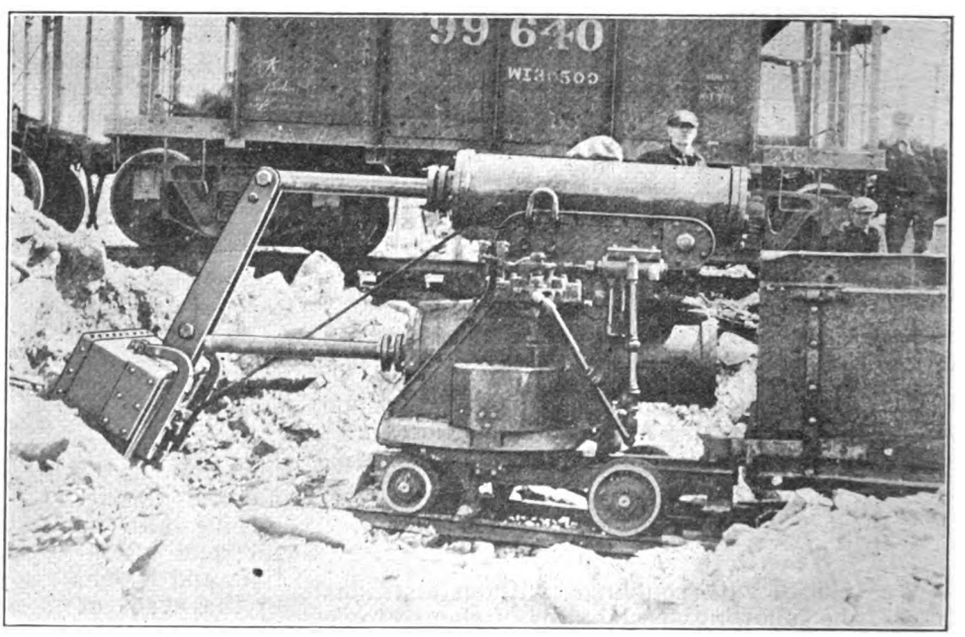
It is of simple, rugged construction, consisting of two air cylinders attached to a rigid dipper arm and pivoted between two steel plates which are supported on a revolving base. The piston rods of the two cylinders actuate the dipper arm and dipper and are so arranged that either can be used as a fulcrum, in the event that blocky ground is encountered, and an effective prying motion obtained which serves to shake up and loosen the hardest pile. The two piston rods are separately controlled, each by its own lever and valve which admits air to either end of the cylinder as desired and the utmost flexibility is thereby obtained.

The swinging engine is a small, square piston engine geared to the revolving gear in the base, which turns on two rows of ball bearings.

The shovel is easy to operate, requiring only one man, who needs no special mechanical skill, as the average miner can run it after a half day's practice.

Durability

Among the outstanding features of the Cole-Goudie Shovel is its freedom from breakdowns. The number of parts is small, there are no chains or cables, no complicated lubricating system and the only gears are those operated by the swinging engine, which are in the base, entirely protected from grit and dirt, and not subject to the shock and strain of digging operations. The air cylinders themselves are automatically air-cushioned and thereby protected from severe shocks and jars. Air hose may blow out but any minor repairs of this nature may readily be made in the working place without removing the machine to the shop.



Getting a Dipper Full

Portability

The larger of the two models weighs approximately two and one-half tons and the smaller less than two tons. They can easily be moved by hand for short distances or coupled to motor train for transfer to other working places. Owing to their design they can travel through low and narrow drifts, clearing chutes, raises, etc., without difficulty.

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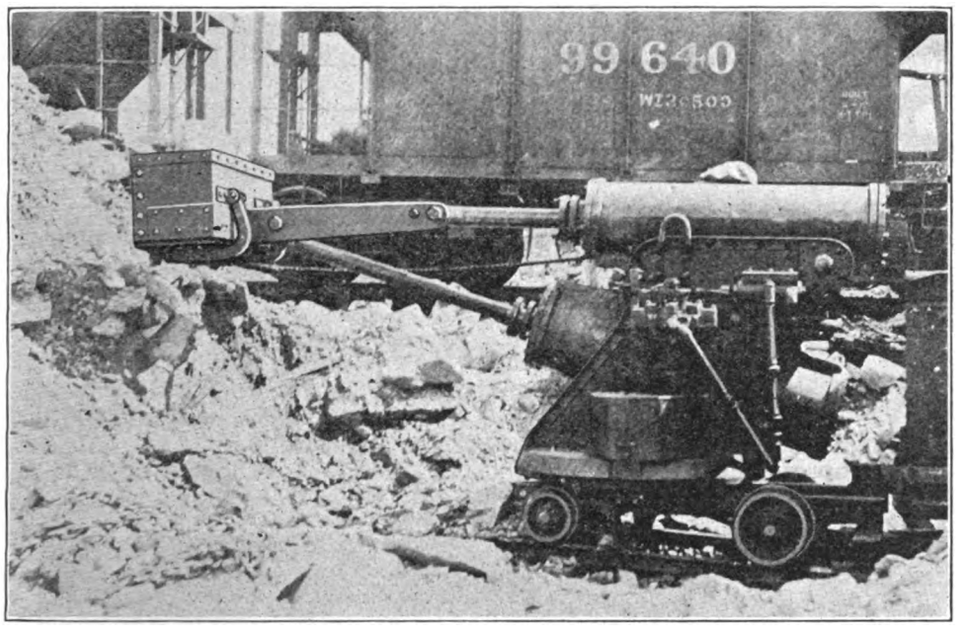
Performance

The Cole-Goudie Shovel will handle with ease any broken material, rock or ore, no matter how "blocky" it may be, and on any kind of a floor, smooth or rough.

Our No. 3 Model will load approximately a ton of material per minute of actual loading time, while the No. 4 Model will load a little over half that amount.



Loaded

The rate of loading throughout the shift will, of course, depend on the rapidity with which cars are switched, although in general the cars can be spotted so that the shovel is not idle more than one-half the total time. A sample of the performance of our smaller shovel is taken from a log of daily operation and shows a total tonnage loaded of 39 tons in 2 hours and 35 minutes of elapsed time, or 1 hour and 5 minutes of actual loading time. In this instance the crew consisted of two men, one miner running the shovel and the other switching cars and tramming to the shaft.

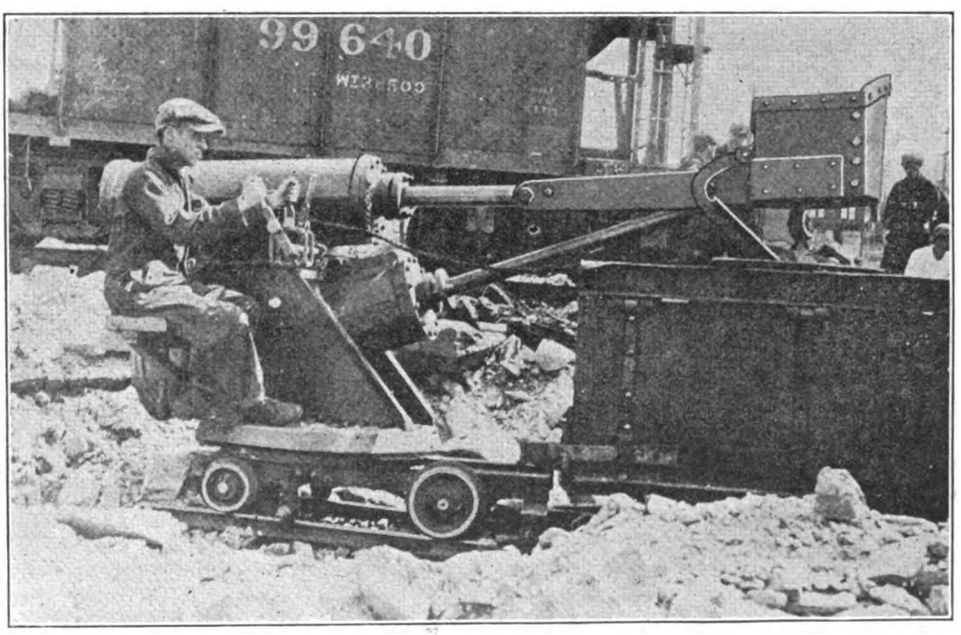
SPECIFICATIONS

	Model 3	Model 4
Weight	5050 lbs.	3700 lbs.
Track Gauge	To Suit Conditions	
Length	7 ft. 3 in.	6 ft.
Width	3 ft. 6 in.	3 ft.
Height	5 ft.	4 ft. 6 in.
Top Cylinder	10½" x 37"	9" x 32"
Bottom Cylinder	12" x 42"	10" x 36"
Reach from center of track	7 ft.	6 ft.
Capacity of Dipper	5 cu. ft.	3 cu. ft.
Wheel Base	36"	30"
Air Pressure	80-100 lbs.	80-100 lbs.
Size of Drift	8 x 10 ft.	6 x 8 ft.

Air Consumption

The amount of air required by the No. 3 Model is approximately 225 feet of free air per minute at 90 pounds pressure, the No. 4 Model requiring approximately 175 feet. This will, of course, depend on the character of the material encountered but is kept to the minimum on account of the fact that advantage is taken of the expansion of air in the cylinders.

Any further information desired will be gladly furnished by the company.



Dumped

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LAKE SUPERIOR LOADER CO.

PROVIDENCE BUILDING, DULUTH, MINN.

Speeds up work

Shuveloder

"The mechanical mucker"

The Machine

Its name tells the whole story. It is a mechanical shovel which loads by shoveling. It digs, lifts and loads just as a man handles a shovel.

Field of Application

Underground—mucking in drifts, stopes and tunnels wherever broken rock or ore is to be loaded into cars.

General Description

The Shuveloder is operated by compressed air, has no engine nor gears. Power is applied through direct thrust air cylinders. No small moving parts to get out of order. Shuveloder is moved by hand. No complicated parts.

Operation

The movements of Shuveloder, Model No. 11, are controlled by three hand levers, and one hand crank for swinging across the drift —all located on one side of the machine.

Operating Crew

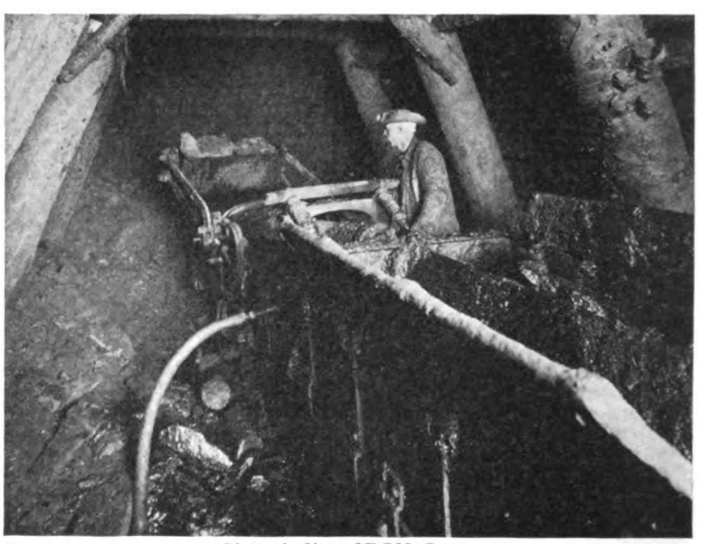
One operator is required, the number of additional men being determined by the distance and size of cars to be trammed.

Advantages

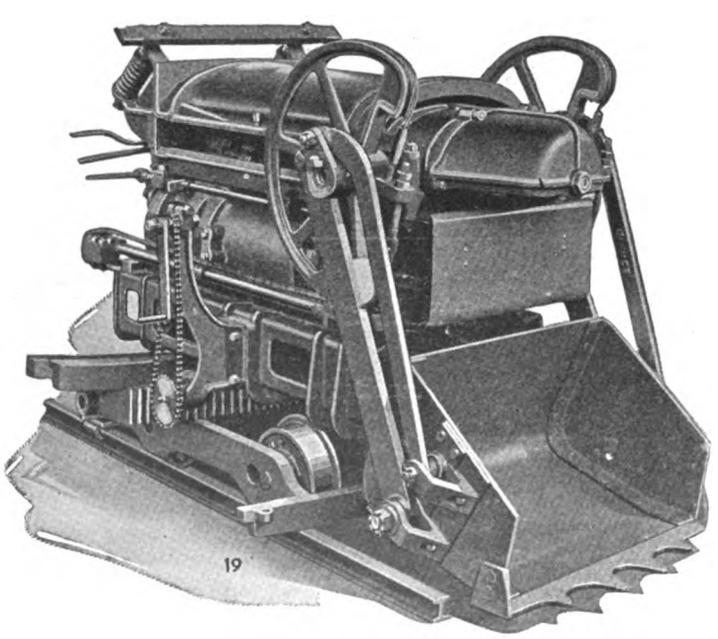
Shuveloder is compact and can be transferred without being taken apart to any place in the average mine. Will work in small tunnels or drifts. No changes required in the mine except the addition of short sections of "move up"track. Operation simple and any ordinary workman can soon learn to run the machine. The capacity of the Shuveloder makes it possible to clean out a heading twice in a shift, thus doubling the output of the ordinary drift, meaning less men required than hand shoveling, and reducing the cost per ton and increasing speed of advance.

Specifications

Minimum size drift 6 ft. wide by 7 ft. high. Dimensions 6 ft. x 4 ft. x 4 ft., weight 4700 lbs. Minimum head room above rail 6 ft. 10 in. Air consumption 150-175 cubic feet. Dipper width 30 in. Dipper capacity 4.45 cubic feet. Loading capacity 45 tons per hour. Speed 6 passes per minute. Air pressure 70 to 110 lbs. Trucks built for any track gauge.



Shuveloding IRON Ore.



Model No. 11 "Shuveloder"

Operating Records

Standard Oil Company, Coal Mine, Carlinville, Illinois—256 tons 8 hours.

Southern California Edison Company, Big Creek, California—9 ft. x 7 ft. tunnel—Average 14 tons per hour total time.

Old Ben Coal Corporation, West Frankfort, Illinois—Loading fire clay without blasting, 15 cars in eight hours. By hand shovelers—3 men —three cars in eight hours.

Steel and Tube Company of America, Anvil Mine, Bessemer, Michigan—27 tons per hour actual loading time—9.4 tons per hour total time (depending on car service).

San Joaquin Light & Power Corporation, Edison, California — 32 tons per hour actual loading time—17½ tons per hour total time (speed affected by car service).

McKinney Steel Company, Ironton Mine, Bessemer, Michigan—33 tons per hour actual time—12 tons per hour total time (car service).

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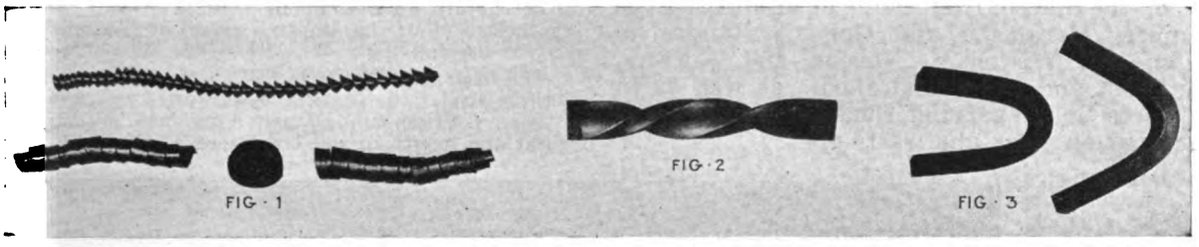
Vindicator Cons. Gold Mining Company, Cripple Creek District—By hand shoveling, advance 5 ft. x 7 ft. tunnel 8 ft. 6 in. every 24 hours—By Shuveloding, advance 6 ft. x 7 ft. tunnel 18 ft. every 24 hours.

The above statements are taken from the average accomplished by the Shuveloder in various properties. The efficiency of the machine and work accomplished depends a great deal upon manner of switching cars and much can be accomplished by giving thought to this detail. With proper thought and care the Shuveloder will pay you good dividends.

ARTILLERY STEEL CASTINGS



Tests of Steel Castings

Shows (Fig. 1) drill cuttings and planer shavings from No. 3 Artillery Steel, (Fig. 2) 1x½ inch cast bar twisted 360 degrees without showing a crack, and (Fig. 3) same size cast bar bent 140 to 170 degrees without fracture. The wonderful ductility of this metal is remarkable. It would require an exceptional grade of forged steel to stand such tests.

The following comparative tests are interesting:

	Elastic Limit Lbs. per sq. in.	Tensile Strength Lbs. per sq. in.
Ordinary Cast Steel	36,000	65,000
No. 3 Artillery Steel	45,000	85,000

Artillery Steel Castings that bend like forgings are the new materials in the Shuveloder.

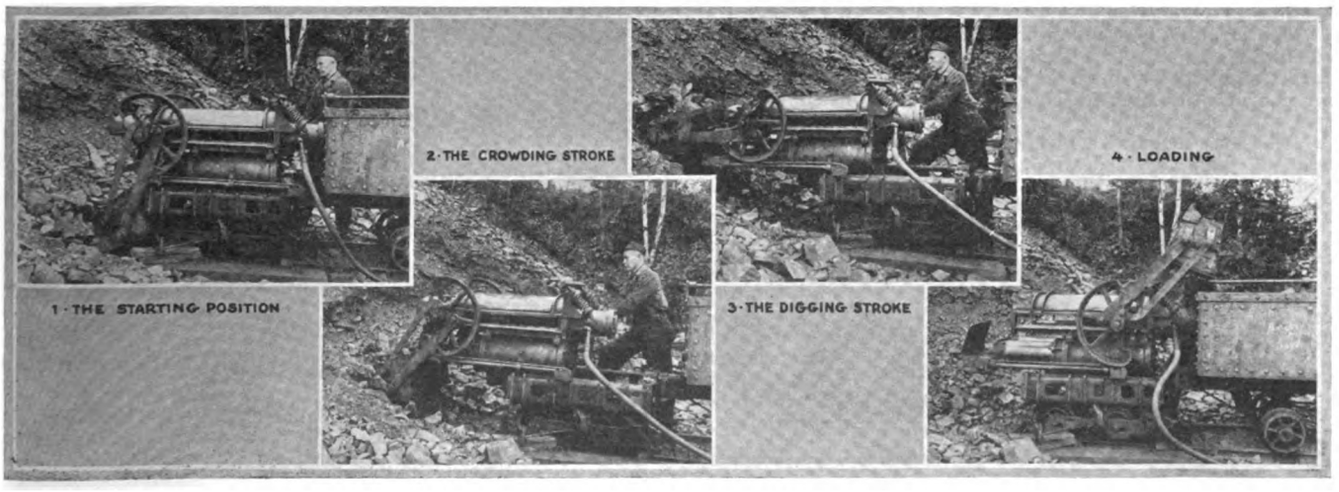
They have replaced ordinary castings of steel and gray iron.

In spite of the extreme severity of underground service there has not been a failure of a single cast part on any Shuveloder built during the past year. This betterment of our war-time record is due to a complete and radical change in materials. War conditions and metals were not of the best. But war's necessities developed the No. 3 Artillery Steel which has proven the biggest step in making the Shuveloder a complete success. It stands every test.

Starting twelve months ago all Shuveloders sold were built of Artillery Steel, and all cast iron parts changed to semi-steel. The Shuveloder has plenty of capacity. These new materials give it shock and wear resisting ruggedness.

Artillery Steel was developed for gun carriages for our army and the French "75s". It combines unusual strength with great ductility and high elastic limit. In war service it had to stand tremendous shocks. Isn't that the ideal material for a shovel?

The Shuveloder is now made in the plant of the Nordberg Manufacturing Co. at Milwaukee, which is a guarantee of careful workmanship and fine selection of materials. It will stand up under your hardest conditions. Day after day, month after month it is right on the job.



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HOAR SHOVEL AGENCY, Inc.

VIRGINIA, MINN., U. S. A.

The Hoar Underground Shovel

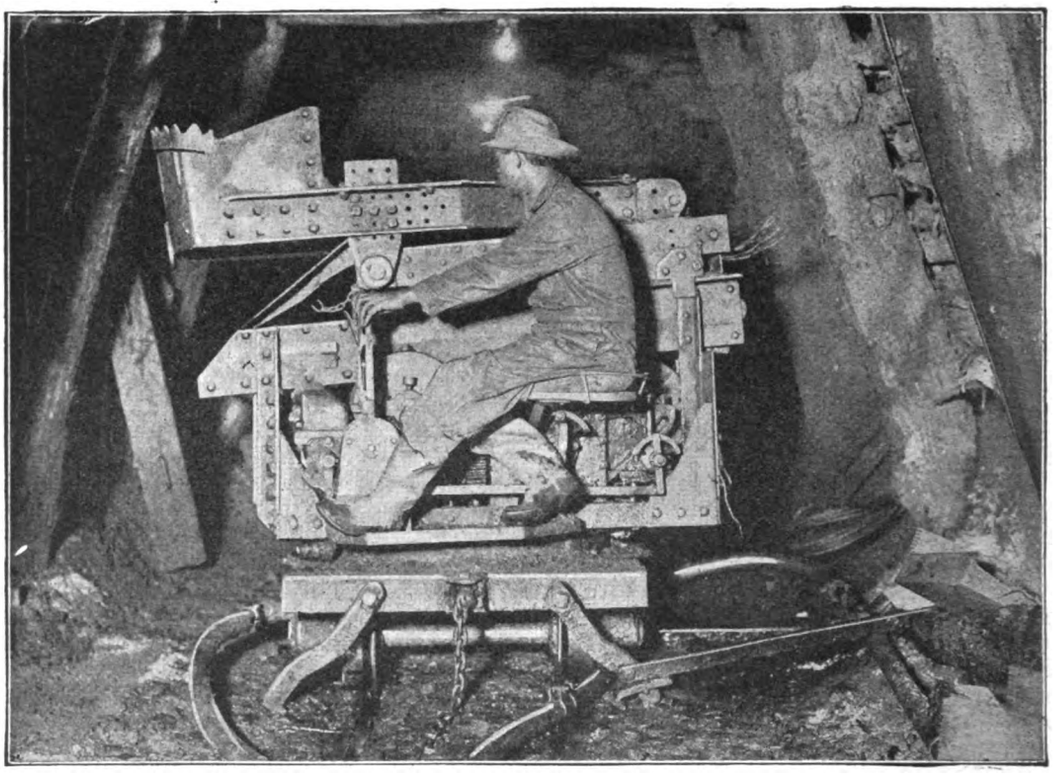
Applications

Hoar Underground Shovels are in use and giving satisfactory service in the Black Hills District of South Dakota, in the zinc and lead mines of Wisconsin, on the Mesabi Iron Range of Minnesota, the Menominee, Marquette and Gogebic Ranges in Michigan and Wisconsin, Nevada and Norway, Pacific Coast and Brazil and Japan, as well as in other places under varying conditions. They are also at work on stock and waste piles.

General Description

The machine is mounted on a truck, which in turn is mounted on 8" wheels in front and 12" wheels at the rear to give clearance over a high car. The body of the machine may be swung in either direction through a complete circle on double ball bearings by a reversible air motor. A second reversible engine, through a self-locking worm gear, drives the table, in which the dipper stick is mounted, forward and backward, giving direct thrust into the breast, as well as the extension needed for dumping and trimming beyond the center of the car.

The control of the engines, and through them of the whole machine, is centered in three levers in front of the operator's seat. Operator's seat and levers are easily **removable for passage of the shovel through a narrow opening. By removing two bolts the dipper and dipper stick can be removed and a few minutes more will take off the table. The No. 2 machine, thus stripped, will go through a passage 42"x42".**



Method of Operation

The machine is a one-man outfit. It can easily be lowered into the mine. It will dig and move around a corner or curve, and up or down hill equally well. The maximum air consumption for the No. 2 machine is 300 cubic feet of free air a minute.

This size machine will handle chunks 22"x20" in section and 18" deep, or if desired, a dipper somewhat shallower and of larger cross section can be provided for handling chunky ore.

As ordinarily built, the No. 2 machine will clear up a circle 15 feet in diameter without moving.

In operation, the shovel is run up to the breast by mine locomotive, or by hand, and clamped to a working section of rail. The machine has power enough to pull up a three-ton car over a dirt covered rail.

The dipper can be dumped anywhere within its reach and the shovel does its own trimming entirely. No hand work is necessary for cleaning up after the Hoar Shovel.

Construction Details

The machine consists of four principal parts: the truck, the body, the table, the dipper and dipper sticks.

The truck is a substantial steel frame; the body is a structural steel frame to which is rigidly fastened the power unit; the table is a cast steel frame mounted on hardened steel rollers and carrying the bearings for the double dipper stick; the dipper mechanism consists of two arms pivoted together to allow the dipper a range of flexibility in working the bottom.

The Hoisting Chain is 7/16" steel, tested to a 4-ton working load.

Dipper Stick and Dipper Arms are adjustable as to height and length to suit conditions of the work. The dipper can be equipped with steam shovel teeth for coarse, rocky material, or saw teeth cutting lip for finer, looser material.

SPECIFICATIONS SHOVEL NO. 2

Swinging Engine	5 h. p.
Lifting Engine	7 h. p.
Crowding Engine	7 h. p.
Dipper	22" wide, 20" deep, 26" high, 4.1 cu. ft., also 6 cu. ft.
Operating Space	7 ft. wide, 6 ft. high
Overall Length	6 ft., 7 in.
Width	3 ft., 6 in.
Height	5 ft., 6 in.
Width, seat and levers removed	42 in.
Height, bucket removed	4 ft., 4 in.
Clean-Up Radius	7'6" to 7'8"
Weight	6000 lbs.
Hoisting Chain	7/16" steel
Air Pressure	80 lbs.
Air Consumption	300 cu. ft. per min., Std. Conditions
Air Connection	1½ in.
Track Gauge	According to order
Wheel Base	37 in.

Special Engineering Service

We will be glad to furnish further particulars or performance figures and estimates on operating costs and savings under your own special conditions. Our Engineering Force is at your service to study your particular problems on the ground and make recommendations for the most economical production of your workings.

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MYERS - WHALEY COMPANY

KNOXVILLE, TENN., U. S. A.

Myers-Whaley Shoveling Machines

The Capacity Loader for Underground Work—Over 100 in Use

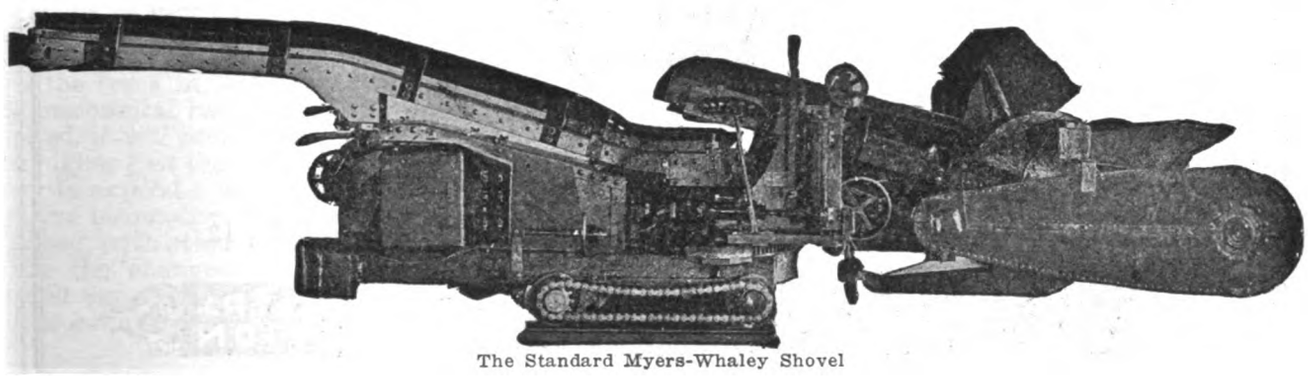
Products

The modern plant of the Myers-Whaley Company is devoted exclusively to the manufacture of Myers-Whaley Shoveling Machines.

Fourteen years of development and experience account for the reliability and consistent performance of these machines.

Application

M-W Machines are used with great economy and satisfaction in loading coal, iron ore, lead ore, copper ore, rock salt, gypsum, limestone, shale, etc., and are standard in the longest tunnel work in America for mucking hardest rock as well as softer material—Machines are applicable to any underground loading.



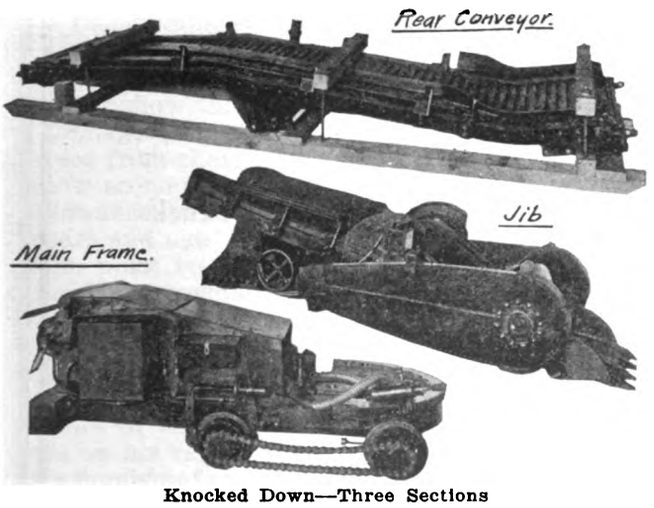
The Standard Myers-Whaley Shovel

Specifications—No. 4 Size

Weight—About 18,500 lbs. in working order.
Track Gauge—To suit mine tracks.
Length—About 25 ft. over all.
Width—5 ft. 4½ in. over all.
Height—5 ft. 4 in. from rail, minim.
Wheel Base—42 inches.
Reach—10 ft. to each side from center of track
Shovel—34 inches wide.
Motor—20 H. P., 250 ft. cable on reel.
Capacity—1 ton per min. in rock.
Will Handle—1,000-lb. lumps.
Shipping Weight—About 22,000 lbs. boxed.
Full Crew—1 Operator, 1 Car Coupler, 1 Helper.
Capacity—200 to 300 tons per shift.

Specifications—No. 3 Size

Weight—About 13,000 lbs. in working order.
Track Gauge—To suit mine tracks.
Length—About 23 ft. over all.
Width—4 ft. 3 in. over all.
Height—4 ft. 3 in. from rail, minim.
Wheel Base—35 inches.
Reach—8 ft. to each side from center of track.
Shovel—33 inches wide.
Motor—15 H. P., 250 ft. cable on reel.
Capacity—1,600 lbs. per min. approx.
Will Handle—800-lb. lumps.
Shipping Weight—About 17,000 lbs. boxed.
Full Crew—1 Operator, 1 Car Coupler, 1 Helper.
Capacity—150 to 250 tons per shift.



Knocked Down—Three Sections

General Features

1. Equipped for Electric or Compressed Air Drive.
2. Operated by one man.
3. Self-propelling; no jacks or clamps.
4. Works on smooth or rough bottom — will spade into coarse rock, making its own bottom.
5. Very flexible, easily and quickly moved from one place to another.
6. Shovel swings over area 18 to 20 ft. wide—Conveyor discharges to rear or on parallel track.
7. Construction is standardized, parts interchangeable.

Catalogs, Treatises on Use of Machines, and other information will be sent on request.

Please mention your conditions when writing.

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SECTION VII

Haulage

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Aldon Company, The
American Car & Foundry Co.
American Frog & Switch Co.
American Mine Door Co., The
American Steel & Wire Co.
Atlas Car & Mfg. Co., The
Baker Car Co.
Baldwin Locomotive Works, The
Card, C. S. Iron Works Co., The
Central Frog & Switch Co., The
Davenport Locomotive Works
Davidson, O. H. Equipment Co.
Easton Car & Construction Co.
Edison Storage Battery Co., The
Electric Storage Battery Co., The
Elliot Frog & Switch Co.
Foster, L. B. Company
Frank, M. K.
General Electric Company
Goodman Manufacturing Co.
Hendy, Joshua Iron Works
Hyman-Michaels Co.
Indiana Foundry Co., Inc.
Ironton Engine Co., The
Jeffrey Manufacturing Co., The
Kenova Mine Car Co.
Kilbourne & Jacobs Mfg. Co., The
Lake Shore Engine Works
Lobdell Car Wheel Co.
Mancha Storage Battery Locomotive Company
Ogden Iron Works Co.
Ohio Brass Co., The
Pennsylvania Casting & Machine Wks.
Porter, H. K. Co.
Ralston Steel Car Co., The
Sanford-Day Iron Works
Southern Wheel Co.
Stafford Roller Bearing Car Truck Corp.
Vissering, Harry & Co.
Whitcomb, Geo. D. Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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MULE HAULAGE IN METAL MINES*

In considering the adoption of any underground tramming system, the following factors must be taken into account: Tonnage to be hoisted daily; distance from stopes or hoppers to shaft; grades and curves to be overcome, and life of the mine.

A system of haulage that may be suited for any one of these conditions may be totally unsuited for the others, and the system decided upon should be that which will show the least cost per ton of operation, taking into account the complete amortization of the capital expense involved when the mine is worked out. For instance, the stopes may be over 2,000 ft. from the shaft, the tonnage desired over 600 tons per day, the grades not heavy, and the track in fair order. These conditions call for mechanical haulage. If the life of the mine is limited, it will probably be better to operate under the higher cost that the use of mules entails, rather than to expend a large amount of money in an expensive locomotive, heavier rails, and an improved roadbed, with attendant disorganization of the mine while the changes are being made, all of which capital expenditure must be amortized before the ore is exhausted.

Hand tramming is suitable only for mines of small output, with tramming distances comparatively short—not over 400 ft. Small cars, of ½- or ¾-ton capacity, are required, as a ton load is too heavy for one man to push unless favored by a grade. The advantage of hand tramming over any other system is the complete absence of any capital expense. With any attempt to increase tonnage, or an increase in tramming distance, the cost of hand tramming becomes prohibitive. Such methods may be used to advantage in cleaning up a small bunch of rich ore, or robbing pillars, where the handling expense is only a small percentage of the total value.

Some Disadvantages of Mechanical Haulage

Mechanical haulage, where conditions are favorable, will show the minimum operating cost. But the tonnage handled must be a maximum and the distance from shaft to stopes must be long enough to show economy in time of hauling, after making all allowance for delay in making up the long trains at shaft and side tracks. Grades, wherever practicable, must be eliminated, or at least eased off as much as possible; curves must be cut out or widened. Unless the track and roadbed are in good condition, the locomotive will promptly search out every weak place and "jump" the track, necessitating vexatious delays in getting it back again, while the work of the mine is held up, and the millman enters on his report "No Dirt." Though it is true that a number of men can be eliminated from underground or put to other work when the change is made to mechanical haulage, the replacement of the engine driver, who may be incapacitated any time from accident or sickness, becomes a serious problem. It is usually an easy matter to put on an extra mule driver or trammer, but a good motor man cannot be picked up on an hour's notice. It is not just a question of operating the engine, although that in itself requires the work of a skilled man. Because of his daily experience over the run, he knows where to put on speed for a grade, where to ease up for a curve, and a knowledge of these matters is most important in the operation of a long train. Furthermore, unless an extra engine is on hand, a breakdown in a vital part of the engine usually entails a shutdown in the mill, so that with a mine running on a close margin of profit, the loss of a day's time with all overhead expenses going on as usual will often completely eliminate the expected economy of the new haulage system for a considerable period.

Limitations of Mule Haulage

Mule haulage is particularly adapted for mines having the following conditions to meet: Open stopes with mining conducted all on one level; tramming distance over 400 ft. and less than 2,000 ft.; many grades, neither very long nor very steep; many curves, some of very sharp radius, and limited life of orebody, but assured for a reasonable period. These conditions are common to many mines, particularly in the zinc mines of Wisconsin and Missouri.

Good mules can be purchased for from $100 to $150 per head. If the roof is high, and there is an incline down which the mules can be taken underground, large mules should be given preference, for the working capacity of a mule weighing 1,100 lbs. or 1,200 lbs. is far more than that of one weighing 800 lbs. It may often happen, however, that there is no incline and the hoisting shaft is small and without means for installing a special mule cage, or that the tramming must be done in low drifts. Small mules can be taken down the shaft without much trouble by suspending them in a special harness and hooking them under the cage or directly to the cable in bucket hoisting. With a careful hoistman, there is not much danger of accident.

Characteristics of Maud

The mule is a much maligned animal. It will do an extraordinary amount of work during a shift's time, patiently and willingly, if given decent treatment and care. It quickly learns the tracks underground, and knows its route in the dark. Reins can be dispensed with after a few days, and no guidance is necessary. A mule will feel its way along a shaky track with uncanny accuracy, and the only light needed is the cap light of the driver. Electric light along the track are of course an excellent investment in every way, and by their aid a much better

*W. F. Boericke, in Engineering and Mining Journal, November 26, 1921.

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speed can be maintained and the track and roadbed kept in better condition. A mule is in no sense a stupid animal, despite frenzied testimony of the skinners to the contrary. Unlike a horse, it is not nervous, and frequent blasting and boulder shooting do not disturb it in the least.

The number of mules required underground will depend on the tonnage and the distance from the shaft. Cars must be taken away from the shovelers as fast as loaded, whether they work on contract or day's pay. If cars are trammed by hand from the stopes to the central gathering station and there made up in trains for the shaft, there must be a sufficient number of mules to get the loads to the shaft and the cars returned without anyone waiting for empties.

The time required by the average shoveler to fill a 16-cu. ft. car (¾ ton) where there is plenty of dirt and not much time needed for breaking up boulders is from six to ten minutes. Tramming to the siding or layby and returning with the empty will take five minutes more. This is at the rate of from four to six cars per hour. Better records will be made by experienced shovelers.

If the shoveling time is fifteen minutes per car, this establishes a maximum for the tramming time. When the haul to the shaft is short, one mule can serve several shovelers without doubling up on the cars. As the distance increases more cars must be provided and two or more cars will be pulled at one time. With trams exceeding 1,500 ft. it is generally necessary to put in a relay station and an extra set of mules to pull to the shaft. The gathering mules will bring the cars singly or in pairs to the station, where they are made up into the longest trains possible and are then taken by heavier animals to the shaft. This means buying about one-third more cars for the mine.

Fifteen miles is the maximum distance that should be expected of a mule working every shift underground. As this is the total distance of the round trips, the mule will pull loads 7.5 miles. Considering a 1,000-ft. haul to the shaft, the number of trips will be about forty. As the distance increases the number of possible trips decreases unless the animal is run to exhaustion. It is therefore better to get the track into such condition that a number of cars can be taken per trip, and the mileage thus decreased.

Good Track Conditions Desirable

Mules should not travel faster than five miles per hour for good results, and if long trains of seven or eight cars are used a speed of three miles per hour is enough. Aside from the danger of accidents and derailments that may occur if greater speed is attained, faster rate than this will wear out the animal quickly and cut down its vitality and tractive effort. It is better to get the track in good condition, improve the oiling of the cars, make an effort to cut down grades and curves, and then put one or two extra cars on the train and cut down the speed, than to make more trips with fewer cars. Mule drivers, especially the younger men, delight in taking chances by racing mules, and a kind Providence apparently protects them from low roof, weak track, and derailments; but it is poor practice and should be discouraged.

A mule needs a 6-ft. clearance between track and roof to work comfortably, and this should be exceeded if possible for large animals. Smaller mules can get along in lower headings, and in some mines, where the clearance was less, spaces have been hollowed out between the ties for them to walk in.

Wherever there is an incline to the mine it is usually advantageous to bring the mules out at the end of each shift. They quickly learn the routine, require little urging to go underground, and still less to come out. Where this is impossible or impracticable, underground stables must be built. These in all cases must be dry. If possible they should be on an upper level or stope, with plenty of ventilation, but not exposed to draft. A sloping floor will aid drainage with individual stalls. The stable should be electrically lighted and kept as clean as possible. A mule tender, whose sole job is to look after the mules, curry, shoe, and feed them, watch their hoofs, and, in case of injury, do a little veterinary work, is worth his pay aside from any humanitarian reasons. If the job is left to the individual mule skinners the animals are likely to be neglected.

Mules should be well fed. Careful figures were kept at a large mine working fourteen mules, to determine the amount and cost of feed for the animals. These mules were all in constant service and averaged about eleven miles per shift, pulling two 16-cu. ft. cars for an average tram of 1,000 ft. The feed needed per month averaged as follows:

Feed	Amount	Per Mule
Hay, tons	3.1	0.22
Oats, bushels	69.0	5.00
Corn, bushels	28.5	2.00

The above figures are rather low in comparison with another mine where twenty-two mules were used on an average tram of 1,450 ft. with layby stations and numerous grades and curves. These were as follows:

Feed	Amount for Year	Per Mule per Month
Hay, tons	83.76	0.31
Oats, bushels	2,424	9.20
Corn, bushels	752	3.00

The cost of feeding will vary with the market price of produce. With hay at $15 per ton, oats at 35c. per bushel, and corn at 60c. per bushel, the cost per mule per day will be about 20c. To this must be added the wages of the mule tender, or a fair allowance of time paid for the attendance, regardless of whether there is an extra man or not. Twenty-five cents per day per mule is not unreasonable for four or five mules, where each driver takes care of his own animal, but where more than eight mules are employed it is better to have one man take care of the entire stable. If the right man is selected he can take care of a large number of animals and the cost of feeding can then be cut to 10c. or 15c.

Rats cause considerable waste around a stable. No more feed should ever be taken underground than is necessary, as the dampness affects it and the rats raise havoc with the grain.

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Not the least value of a mule is his ability to exceed his ordinary tractive effort greatly over a short distance. For a short pull, the mule can make some astonishingly steep grades. Regardless of his usefulness on a long haul, therefore, the mule has an undisputed place in gathering cars for the trains and in clean-up work where tracks are rough and only intended for temporary use, the curves sharp, and the grades steep. The following figures, from actual practice, show what can be done. The cars used were 16.5 cu. ft.

Length of Grade, Feet	Per Cent. of Grade	Number of Cars Pulled by One Mule
55	6.6	2
35	15.0	1
88	8.7	2
34	12.8	1
31	14.3	1
130	7.0	1 or 2

The ideal grade for haulage is usually taken as between 0.5 and 1 per cent, the gradient of equal traction, where the power needed to pull back the empties is just equal to that required to overcome the friction of the loads coming down hill. In actual mine work, unless on long drifts that are carefully surveyed and driven on line, such an ideal condition is rarely encountered. Tracks will run up and down with variations in the floor of the orebody. Care in selecting the trackway and sometimes changing the line or cutting out a high spot will be amply repaid in added efficiency of the mules.

Mule Haulage Expense

The cost of mule haulage is made up of the following items: Cost of feeding; cost of attendance; wages of mule drivers, and depreciation.

The cost of feeding has already been given as 25c. per day, but it varies somewhat with the market price of supplies, although it is nearly a constant charge, whether the mules are worked or not. The cost of attendance can be covered by 25c. per day, and this will also pay for such supplies as are needed, shoes, nails, harness, and other requirements. Wages of mule drivers are about $3 per day on the present scale. They are generally employed on straight time, not contract.

A mule with good care and feed will thrive underground. Barring accidents, there is no reason why mules should not remain below six years or longer, and then, if in good health, they have a considerable value for farm work on the surface. If a mule costs $150 and is worth $50 when taken out, over a six-year period a depreciation figure of $16 per year, or 5c. per day, is enough. The total expense of mule and driver per day is, therefore, $3.55.

The ton mileage obtained will vary with the conditions in the mine, and I am quoting some typical instances. In all cases a 16.5-cu. ft. mine car, weighing 800 lbs. empty, with solid body, loose wheels, plain bearings, lubricated with grease through slot holes bored in the hubs, was used. Track gage was 22 in., with 16-lb. rail.

At mine No. 1, the average tram was 1,450 ft. Two cars were hauled per mule. The grades were against the load, the worst pull being 300 ft. of 3 per cent grade. The curves were sharp. No brakes were used on empties; the drivers held back the cars by placing their hand on the mule's rump. The mules were worked hard on account of the long tram, and obliged to travel at a run on the return trip. Data were as follows:

Average tons trammed, per shift	180
Average tram distance, feet	1,450
Number of mules	4
Mineral tons per mule	45
Miles traveled per mule	12
Ton-miles per mule	12
Cost per ton, cents	7.9
Cost per ton-mile, cents	30

At mine No. 2 the average tram was 2,613 ft. This was covered by using a relay of big mules that picked up the loads at the layby station 1,000 ft. from the shaft and pulled them there in eight-car trains. The gathering mules pulled two cars over fair tracks with less than 1 per cent grade against the loads. On account of the long tram they were worked hard and were worn out soon. This mine was soon afterward changed over to gasoline haulage. The comparative figures are:

Average tons trammed, per shift	288
Average tram distance, feet	2,613
Number of Mules	9
Mineral tons per mule	32
Miles traveled per mule	15.8
Ton-miles per mule	15.8
Cost per ton, cents	10.9
Cost per ton-mile, cents	22.4

At mine No. 3 conditions were better. The average tram was 2,000 ft. over a level grade with curves well proportioned. Large mules were used, taking trains of six cars to the shaft. These traveled at slow speed, about 3½ miles per hour. The figures follow:

Average tons trammed, per shift	400
Average tram distance, feet	2,006
Number of mules	3
Miles traveled per mule	8.5
Ton-miles per mule	26
Mineral tons per mule	64
Cost per ton, cents	5.2
Cost per ton-mile, cents	14.0

At mine No. 4 conditions were excellent for mule haulage. Cars were taken from the gathering point, 1,483 ft. from the shaft, by two mules per shift, in trains of four cars. The track from the layby station to the shaft dropped uniformly 1½ per cent in favor of the loads on a straightaway run. The track was in good condition and was electric lighted. The cars ran down the grade by their own weight after being started, and the mules went at an easy trot, about five miles per hour, which did not exhaust them. They could easily have taken down a much longer train, but four empties were their limit on the return trip. Brakes were not needed except at the end of the run, when a wheel of the last car was spragged. Comparative data follow:

Average tons trammed, per shift	256
Tram distance, feet	1,483
Number of mules	2
Mineral tons per mule	128
Miles traveled per mule	18.1
Ton-miles per mule	36.3
Cost per ton, cents	2.8
Cost per ton-mile, cents	10.1

The noteworthy mileage made by these mules was no doubt due to the down grade with the loads, which eliminated all hard pulling.

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Practical points then seem to be as follows: Use the largest-size mule that can be worked in the drifts; keep track and roadbed in the best possible condition, with the grade, if any, in favor of the loads; load the mule to his capacity (if the grade is about 1 per cent this will be determined by the number of empties he can pull back), and maintain a constant, steady speed—frequent spurts may satisfy the sporting proclivities of the driver but they detract from the mule's efficiency.

It is frequently the case, as in mines No. 1 and No. 2, that the cost per ton may go up while the cost per ton-mile goes down. The same number of mules may take a less number of cars but cover a much longer distance, thus decreasing the latter but increasing the cost per ton, and, until both figures are known, criticism cannot be intelligently made. Knowing the time required for a round trip to the shaft from the stopes, plus delays in coupling and uncoupling cars at the stations, a close guess is possible at the number of mules needed to take care of any tonnage from any distance. For instance, in considering a tramming distance of 1,000 ft., with a tonnage of 300 required, four-car trains are possible, and the estimated time for a round trip, including delays, is seventeen minutes. Twenty-eight trips per eight-hour shift are then possible, mineral tons per mule will be 112, and three mules will be required. The cost per ton will be 3.1c., and the cost per ton-mile, 16.7c.

It is rare that the tramming problem can be handled by so simple a calculation as this. Conditions are constantly changing, and, in an effort to speed up production, a demand for more cars is made, or more speed by the trammers, and the ground boss has a new problem on his hands. A double track is always desirable, and an extra mule will earn his keep many times over in helping out in a pinch.

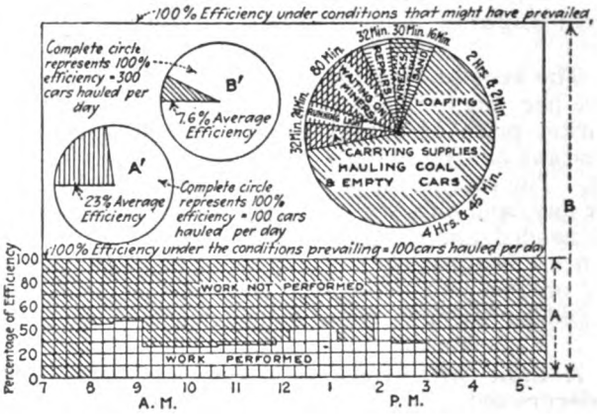
STORAGE BATTERY LOCOMOTIVE AS APPLIED TO MINE HAULAGE*

A thorough visualization of the subject would contemplate a comparative analysis of haulage machines and batteries of various types; the relationship of the storage-battery locomotive to other types of mine haulage should be considered and limiting factors in each case should be carefully developed. This paper will briefly deal with these factors.

About 1913, several large manufacturers sought to produce a reliable storage battery locomotive. For two or three years, although a satisfactory battery and thoroughly substantial mechanical parts and motors were available, the development was slow, because of the failure of the manufacturers thoroughly to understand mine requirements.

The interest of the mine owner in haulage is concerned solely in the number of tons of coal or ore that he can safely haul in a day and the cost per ton of this work.

In the coal mines having the lowest haulage costs there will be found: Entry trackage of not less than 40 lb. weight, well supported and well maintained on ties; room rails of 20 lb.; cars of the greatest cubical content permitted by the height of the seam (in low seams) or (in high seams) by the ease of loading. In well-managed soft coal mines where the shovel is used, cars with a cubical content of 235 cu. ft. are found. The track gage is not less than 36 in. and usually is over 40 in. The trips contain from 25 to 50 cars and the main haulage locomotives are from 10 to 30 tons. There is double track on the main headings, good voltage at the working centers, the gathering locomotives are from 4 to 6 tons, and the workings are concentrated.



Graphic Analysis of Daily Performance of Locomotives

The above in its relationship is practically characteristic of mine haulage in general.

Similar tests several weeks later after power and other conditions had been improved, indicating a 100% increase in productive effort and proportional decrease in equipment needed for work produced, power consumption and other incidental costs.

This chart represents one step in a test carried from boiler to face of coal.

A = Possible work under prevailing conditions.

B = Possible work under conditions which might have prevailed.

Advantages of the Storage Battery Locomotive

Within the car limits indicated, with a concentration of work, general grades not exceeding 6 per cent., the work for the storage-battery locomotive is collecting the cars from a number of places or rooms and taking them to a siding where the trip is made up for the heavy locomotives.

*New York meeting of A. I. M. & M. E. Charles E Stuart.

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Under these conditions, the storage-battery locomotive containing motors and batteries of ample capacity for the actual cycle of duty has the following advantages:

1. It is unnecessary to string trolley wire and bond tracks away from the main haulage ways.

2. In thin coal, it is unnecessary to brush; that is to take up bottom in order to make height necessary for mules.

3. No time is lost by making cable connections with the trolley on entering rooms, nor by cutting the reel cable and splicing it where cut.

4. The chance of personal contact with the trolley wire is absent.

5. In a gassy mine, away from the well-ventilated headings, the absence of a spark at the wheel or the trolley may be a vital consideration. In those mines where safety lamps are required, it is only a matter of time before the use of the trolley and reel locomotive for gathering will be prohibited. The storage-battery locomotive can be, and is being, made gas-proof and will pass the tests of the U. S. Bureau of Mines.

6. The speed and haulage capacity of the machine measured in pounds drawbar pull, will enable it to displace a number of mules and drivers and should materially lower the cost of gathering.

7. An invaluable consideration is the independence of the storage-battery locomotive with respect to either substation or power plant during idle days. At such times a storage-battery locomotive may be used for handling supplies for other purposes.

The writer is now working on plans for a mine in which alternating current will be used for all stationary motor drives and for mining machines. For a short time, animal haulage will be the cheapest; but when the economic limit for this haulage is reached, it is proposed to purchase a charging set and storage-battery locomotives. In many cases, wit ha small mine, the storage-battery locomotive will be the most economical haulage unit for the life of the mine. With larger development, the third step would be the introduction of the heavy type locomotive and the division of the storage-battery locomotive to gathering.

Conclusions

To sum up, the storage-battery locomotive is proving a complete success and a means for reducing costs as well as risk of accident, where properly applied. Its failure at any mine will be accounted for by one of the following:

1. A duty cycle in excess of battery capacity; this has been the most frequent cause for failure.

2. Misapplication is a common error; that is, the effort to use the storage-battery locomotive where mule power is cheaper or where man power in conjunction with the strictly haulage type of locomotive would be cheaper.

3. Failure to select a locomotive that will stand the abuse of mine practice.

4. Failure to provide a reasonable amount of care and attention.

MAINTENANCE OF TROLLEY-TYPE LOCOMOTIVES*

The three principal troubles which locomotives are apt to develop in service are open circuits, grounds and short circuits. If the trouble is not immediately apparent, it is well to make the following tests in regular order, making use of a magneto or lamps in series with two test leads. If the trouble is surmised to be an open circuit, first make certain that the motor brushes make good contact on the commutator; also remove the trolley from the wire and globes from the head lamps. Test between the trolley wheel and the terminal marked "T" or "trolley," in the controller. If a circuit is found, test between the first and last fingers of the resistance leads. If no circuit is obtained here, disconnect the resistance leads from the terminals one by one and thus isolate the trouble. If a circuit is obtained, the open circuit is probably in one of the motors and can be located by testing the motor leads.

If it is apparent that the trouble is a ground, proceed in a similar manner, testing from the trolley wheel to the motors, first, however, disconnecting all permanent grounds and notching up the motor brushes. Isolate the ground by disconnecting the circuit, section by section. Attach one lead of the magneto or lamps to ground and test each part in turn with the other.

To insure the proper connection of motors when reinstalled after overhauling, wire a fibre tag to each motor lead and the corresponding tag to the lead connected with it. Adjust parts as follows with the spring scales: Pressure of controller fingers, 2½ lbs.; pressure of trolley on wire at the average height, about 12 lbs. to 15 lbs.; pressure of motor brushes, between 3 lbs. and 4 lbs.

*Frederick Krug, Electrical World, November 5, 1921, and Lefax, December 23, 1921.

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The feeder connections to the trolley wire should be inspected occasionally as the repeated passage of the locomotive will in time often cause the connections to work loose. Connections at sectionalizing switches will also need attention now and then. Wherever possible it is advisable to give the rail joints periodic tests in order to maintain them at their highest efficiency. The fishplate bolts should be kept tight so as to eliminate as much vibration of the rails as possible. Cross bonding every 250 ft. or so will help maintain the continuity of the circuit in event of the breakage of the bonds on one section of rail. It is also good practice to bond to water pipes or air lines where they parellel the track and then run a lead from these pipes to the power house. If the voltage at the locomotive at maximum load is much less than 80% of the voltage at the power house. It is generally advisable to install additional feeders, first making sure that the loss is not due to excessive resistance in the return circuit. The best practice calls for an equal loss of voltage in the feeder wire and in the track circuit.

TROUBLES TO LOOK FOR ON MINE LOCOMOTIVES

TROUBLE	CAUSE
1. Failure to operate on any position of controller.	Open circuit, usually in wiring. Ground connection disconnected or burnt off.
2. Locomotive operates on some notch after first.	Open circuit in resistance grids between notch it starts on and last previous notch.
3. Locomotive operates with motors in parallel, but not in series.	Open circuit in one motor, either in connection or the field.
4. Circuit breaker opens on some notch of the controller, usually the first.	Ground on resistance or on one of the motors.
5. Locomotive operates in series, but circuit breaker opens with controller in parallel.	Ground on one of the motors.
6. Jerky rotation of armature and bad sparking.	Open circuit in armature.
7. Local heating of armature and sparking and pitting of one spot of commutator.	Short circuit in armature.
8. Heating and higher speed of armature and perhaps flashing.	Short circuit in field.

Locomotive Inspection and Maintenance Schedule

DAILY

Trolley Pole—See that the trolley-pole runs freely and that harp, wheel axle, springs, bushings and trolley pole cabe are in good condition for the day's run. If any part is found defective, change for spare trolley pole and leave in shop for repairs. Put a few drops of oil on the swivel base and trolley-wheel axle.

Controller—Examine carefully for any loose parts. Smooth down any slightly burned fingers or contact segments and change any that are badly burned, making sure that they make good contact by turning controller off and on several times. Clean controller thoroughly and then put a very light coat of vaseline on the segments and fingers and a few drops of oil on the shaft bearings and pawls.

Motors—Note condition of commutator and see that brushes work freely and make good contact.

Brake and Driving Boxes—See that the entire braking equipment is in satisfactory condition for the day's run, making sure to note whether brake shoes are wearing evenly. If not, adjust. See that the wool waste in the driving boxes is touching the axle and is well saturated with oil. Make sure that covers fit tightly to prevent the entrance of foreign matter.

WEEKLY

General—Clean locomotives thoroughly and blow out with compressed air. Repeat the regular daily inspection and make any changes for which time could not be found during the week. In addition, examine the following:

Circuit Breaker—Clean contacts and put a few drops of oil on all working parts.

Wiring—See that all connections are tight and that the cable is in good condition. Replace marker tags before they become unrecognizable, so as to keep the machine in readiness for disconnection and reconnection of the wiring at short notice. See that all joints are well taped and give the cable an occasional coat of black insulating varnish.

Resistance Grids—After thoroughly cleaning and blowing out, examine for any tendency to buckle and replace any that are likely to cause short circuits. Make sure all parts are tight.

Brasses—Examine journal brasses in the driving boxes and replace those worn too thin. Repack any boxes in which the waste has become dirty.

Bearings—Note the condition of the armature and axle bearings and see that the housing contains sufficient oil to keep the wool waste well saturated. Every two weeks put a small amount of grease on the ball bearings of the motors that are thus equipped.

Gears and Pinions—Examine carefully to see that pinions are tight and not badly worn. See that the gear case fits snugly and prevents the entrance of foreign matter. Grease the gear wheel.

Brake Shoe—Replace brake shoes when worn too thin.

Motors—Remove tap from bottom of motor frame to draw off any oil that may have collected. Remove top cover and clean brush holders and windings with a cloth. Blow out thoroughly and replace. If commutator is rough and blackened, clean with No. 00 sandpaper on the end of a block of wood. To do this remove the brushes of the motor to be cleaned and run locomotive with the controller in "parallel" by the other motor.

SEMI-ANNUAL

Remove motors from locomotive and disassemble. Clean thoroughly and give the field coils and armature a coat of black air-drying varnish if necessary. See that all connections and wiring are in good condition. Replace any worn parts of brake rigging. Change armature and axle bearings if found worn. Change wheels and axles if necessary and put washers on axles if there is play between wheels and frames. Thoroughly overhaul controllers and put locomotives in first-class operating condition.

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ELECTRIC HAULAGE SYSTEM IN BUTTE MINES

Prior to 1902, tramming ore from stopes to shafts, in Butte mines, was done by man or animal power. Demand for greater tonnage and the need for more improved methods of tramming resulted in the installation of compressed-air locomotives in a few mines. These locomotives were not generally adopted, because of a number of limiting features. They were superseded by electric trolley locomotives.

There are now operating in the Butte mines of the Anaconda Copper Mining Co., 185 trolley-type locomotives, each of which has replaced five animals.

The haulage conditions in this company's mines have many advantageous features that are not always found in underground mine workings. The drifts and crosscuts are large, approximately 5 ft. wide by 7½ ft. high, and have curves of no less than 18 ft. radius; and the roadbeds of the drifts and crosscuts have a uniform grade of 0.5 per cent. in favor of the loaded trips. In all of the mines, except two, the track gage is 18 in., and all tracks in the main haulageways are laid with 25-lb. rails. The average haul is 1,500 ft., but a number of hauls are approximately 3,000 ft. long.

Usually a train consists of ten loaded, roller-bearing cars. Each car weighs, when empty, 900 lbs. and holds 14 cu. ft. of ore, which weighs about 1,800 lbs., thus the total weight of a train, without the locomotive, is 13½ tons. Normally, ten trips of ten cars of ore each are required per shift of 8 hrs. on each mine level; this does not include, however, the tramming of waste or supplies. Waste is generally hauled during the time the ore haulage is light, as the material is usually trammed against the grade from the shaft to the stopes for back-fill. During a working day the locomotives are in service 16 hrs., hauling an average of 245 loaded cars, and returning the same number of empties.

A mine locomotive with a drawbar pull of 750 lbs. would perform the work that has been outlined. To resist the abuse to which a mine locomotive is always subjected, larger equipment has been installed. The trolley locomotives now in service have a drawbar pull of 1,450 lbs., a speed of 5.3 mi. per hr., and weigh 3½ tons. The trolley wire is carried in an inverted wooden trough placed at one side of the tracks and made of 2 by 8-in. strips for the back and 1 by 8-in. boards on each side.

As the trolley wire is a fire hazard and a potential danger to the workmen and as it limits the use of a trolley locomotive, particularly in the gathering operation, the storage-battery locomotive has been installed in a number of the Anaconda mines. The first storage-battery locomotive put into operation demonstrated that it was a success and, as a result, thirty additional machines were purchased, and most of them are in operation. The total weight of the locomotive is 4½ tons. It is rated at 1,500-lb. drawbar pull at 3½ mi. per hr. on level track, with a maximum drawbar pull of 2,500 lbs. for starting and accelerating.

The cost of a trolley wire and track-bonding installation on the long hauls is about equal to a set of storage batteries for a locomotive, hence there is little difference in cost between a trolley locomotive and a storage-battery locomotive installation. The cost of maintenance of the two types of installation has been in favor of the latter, as the labor necessary to keep the trolley wire in alignment with the rails, due to the movement of ground in a number of the mines, and the constant repairing of the guard strip over the trolley wire, involves large expenditures.

There are now operating in the mines 22 storage-battery locomotives, hauling an average of 245 loaded cars and returning the same number of empties in a 16-hr. day.

—C. D. Woodward, Butte, Mont.

PERFORMANCE OF COMBINATION STORAGE BATTERY—TROLLEY LOCOMOTIVE

In response to a request for operating costs of storage battery locomotives, the following tabulation has been taken from a paper entitled "Storage Battery Locomotives As Applied to Mine Haulage," by Charles Stuart, an abstract of which is printed in this section. This table was compiled after a careful study for a full month at the Lynch mines of the United States Coal and Coke Co., at Lynch, Ky. Monthly and daily averages are given

Locomotive No. 906—Type "D. T."

FIXED OPERATIVE COSTS

Average hours worked per day	10.7
Driver's wages—70 cents an hour	$203.00
Coupler's wages—65 cents an hour	188.70
Motor house rental—20% of cost of superintendence	3.72
Interest on investment, 6%	40.92
Depreciation on locomotive, 10%	38.13
Depreciation on battery, 7 year life	50.22
Supervision, cost per locomotive	16.20

MAINTENANCE COSTS PER MONTH

Current consumption, kilowatt-hours	670
Current costs 0.0175 per kilowatt-hour	$11.71
Repair parts, $150 per locomotive per year	12.71
Repair labor, 1 hour per day	24.80
Time for repairs	31 hrs.
Repair shop cost, 20% of parts and labor costs	$ 7.44
Distance covered per day	15.4 miles
Number of trips per day	3.2
Number of loads pulled per day	58.3
Number of empties spotted per day	59.3
Average distance covered per trip, feet	25,236
Average distance traveled per car, feet	690
Average level distance per trip of total, 43%, feet	10,851.5
Average distance per trip of total, 35%, average of 7.7% against loads, feet	8,832.7
Average distance per trip of total, 22%, average of 4.1% in favor of loads, feet	5,551.9
Time hauling loads	75 hrs. 49 min.
Time spotting empties	87 hrs. 10 min.
Time lost waiting for empties	24 hrs. 30 min.
Time lost waiting for loads	18 hrs. 38 min.
Time lost, other reasons	73 hrs. 18 min.
Average time per car, full trip minutes	3.3
Load weight in cars, coal and locomotive, hauled per trip, tons	97.6
Load weight in cars and locomotives, hauled per trip, tons	45.05
Net tons coal hauled per day	151.8
Mules replaced	8
Men replaced	8

TOTAL COSTS

Fixed costs, per month	$540.89
Maintenance costs, per month	56.66

SUMMARY

Tons hauled per month	4,098.4
Total cost per month	$597.55
Average cost per ton	0.145
Mules replaced	8
Mule drivers and crab men replaced	8
Cost of operating, per mile	$ 0.135

REMARKS

Previous equipment used in same section, 8 mules, 8 men and 2 crab units.

Feed @ $20.00 per month each mule	$ 160.00
Depreciation @ 25% at average cost of $175.00	29.16
Interest on investment @ 6%	7.00
Shoeing, stabling and harness	16.00
Drivers and crab men at actual time locomotive worked	1,624.00
Monthly costs	$1,836.16
Locomotive costs, monthly	597.55
Saving monthly	$1,238.61
Saving yearly	$14,863.32

COMPARATIVE RESULTS

Per ton cost hauled by mules	$0.448
Per ton cost hauled by locomotives	$0.145
Per ton saving	$0.303

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Specimen Form Sheet for Haulage Locomotives

(Information Desired by Manufacturers)

Type Required

Electric
Compressed air
Gasoline
Steam
Storage Battery

Size or Weight Locomotive Required

Number Required

Dimensions

Maximum width locomotive can have
Maximum height locomotive can have
Is it necessary to take apart to install (in case of shaft mine)?

Track

Weight of rail..... lbs. per yard
Exact gauge of track on straight haul
Exact gauge of track on curves
Radius of shortest curve in feet from center of track
Length of shortest curve
Average length of haul

***Grades**

Maximum grade in favor of load is ... % for ... ft.
Maximum grade against load is ... % for ... ft.
What is the average grade and is it in favor or against the load?
Length of maximum grade (in favor of load ....
Length of maximum grade (against load ....
If curves occur on grade, what is radius and grade?

Haulage Conditions

Width of entry
Height of entry over rail and at lowest point in rooms
Clearance each side of track
Number of cars to be hauled per day
Number of cars per trip
Number of places to haul from

†Cars

Length of pit car
Width of pit car
Weight of pit car and load
Diameter of pit car wheel
Length of wheel base
Do pit cars have center or side bumpers?
Height from top of rail to top of bumper
Height from top of rail to bottom of bumper
Width from outside to outside of bumpers
Height from top of rail to center of hitching
Dimensions of coupling—length and width, inside and outside

Trolley Wire (Use this for Electric Locomotives)

Location—Right or left side going toward face
Distance of trolley wire outside of track rail
Highest point in trolley wire above rail
Lowest point in trolley wire above rail
Location of motorman
Voltage
For gathering locomotive, give longest haul locomotive must make using cable

Gasoline Locomotives

Is haul inside or outside?
Kind of liquid fuel available
Altitude above sea level
State ventilating conditions

Compressed Air Locomotives

Elevation above sea level of compressor location
Will compressor be operated by steam or electric power?
If steam, state pressure
If slope mine, give length and pitch
If shaft mine, give depth
Give distance from convenient location for compressor to head of shaft or slope
If drift mine, state distance from convenient location for compressor to parting outside where locomotive will deliver loaded cars.

Storage Battery Locomotives

What source of power, giving voltage, etc., will be used to charge locomotive batteries?
Number of entries to be served for gathering locomotive
Number working rooms to be served on each entry
Give a schedule of the service required of the locomotive, stating when at work and when idle throughout the 24 hours?
Will it be possible to give the battery a boosting charge at any time during the day?
*Give complete information on grades

*A sketch, or better, a map of your tracks with notations thereon in regard to grades and elevations at various points and referring to the weights of, or number of carloads of material which must be hauled between the various points per hour or in 5, 8 or 10 hours, usually gives a much clearer idea of your requirements than it is possible to give by tabulated method. A profile of important roads, or those where excessive or irregular grades occur, may also suggest important alterations in the equipment If haulage roads are to be lengthened, indicate which ones, and at what rate in feet per year they may be expected to increase in length. If the quantities to be hauled will increase, state how soon and how much. Also what lengths of haul and what quantities you wish to provide for in making the initial installation.

†If possible, it is expedient to furnish drawings of cars showing bumper and draw-bar so that locomotive may be arranged to suit.

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Gross Tons Hauled by Electric Locomotives

TABLE A. HAULAGE CAPACITY OF ELECTRIC MINE LOCOMOTIVES EQUIPPED WITH CAST CHILLED WHEELS

This table gives the drawbar pull in pounds and the haulage capacity in tons for a given weight of locomotive on various grades, when equipped with chilled cast-iron wheels. A co-efficient of friction of 30 lb. per ton has been assumed on level track, and 20 lb. per ton for each per cent. of grade.

Grade	Level		1%		2%		3%		4%		5%		6%		7%		8%		9%		10%	
Loco. Wght., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons
3	1200	40	1140	23	1080	15	1020	11	960	9	900	7	840	6	780	5	720	4	640	3	600	2
4	1600	53	1520	31	1440	20	1360	15	1280	12	1200	9	1120	7	1040	6	960	5	880	4	800	3
5	2000	67	1900	38	1800	26	1700	19	1600	15	1500	11	1400	9	1300	8	1200	6	1100	5	1000	4
6	2400	80	2280	45	2160	31	2040	23	1922	17	1800	14	1680	11	1560	9	1440	7	1320	6	1200	5
7	2800	93	2660	53	2520	36	2300	25	2240	20	2100	16	1960	13	1820	11	1680	9	1540	7	1400	6
8	3200	107	3040	61	2880	41	2720	30	2560	23	2400	18	2240	15	2080	12	1920	10	1760	8	1600	7
10	4000	133	3800	76	3600	51	3400	38	3200	29	3000	23	2800	19	2600	15	2400	13	2200	10	2000	9
12	4800	160	4560	91	4320	62	4080	45	3840	35	3600	28	3360	22	3120	18	2880	15	2640	13	2400	10
13	5200	174	4940	98	4680	67	4420	49	4160	38	3900	30	3640	24	3380	20	3120	16	2860	14	2600	11
15	6000	200	5700	114	5400	77	5100	57	4800	43	4500	35	4200	28	3900	23	3600	19	3300	16	3000	13
17	6800	226	6460	129	6120	87	5780	64	5440	49	5100	39	4760	32	4420	26	4080	21	3740	18	3400	15
18	7200	240	6840	136	6480	92	6120	68	5760	52	5400	41	5040	34	4680	28	4320	23	3960	19	3600	16
20	8000	267	7600	152	7200	103	6800	75	6400	58	6000	46	5600	37	5200	31	4800	27	4400	21	4000	17
25	10000	330	9500	190	9000	118	8500	95	8000	72	7500	58	7000	46	6500	38	6000	32	5500	26	5000	22
30	12000	400	11400	227	10800	156	10200	113	9600	87	9000	70	8400	56	7800	46	7200	38	6600	32	6000	26

TABLE B. HAULAGE CAPACITY OF ELECTRIC MINE LOCOMOTIVES EQUIPPED WITH STEEL-TIRED WHEELS

This table gives the drawbar pull in pounds and the haulage capacity in tons for a given weight of locomotive on various grades, when equipped with steel-tired wheels. A co-efficient of friction of 30 lb. per ton has been assumed on level track, and 20 lb. per ton for each per cent. of grade.

Grade	Level		1%		2%		3%		4%		5%		6%		7%		8%		9%		10%	
Loco. Wght., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons	Draw-bar Pull, lb.	Haul-age Cap., tons
3	1500	50	1440	29	1380	20	1320	15	1260	12	1200	9	1140	8	1080	6	1020	5	960	4	900	4
4	2000	70	1920	39	1840	26	1760	20	1680	15	1600	12	1520	10	1440	8	1360	7	1280	6	1200	5
5	2500	84	2400	48	2300	33	2200	24	2100	19	2000	15	1900	13	1800	10	1700	9	1600	8	1500	6
6	3000	100	2880	58	2760	39	2640	29	2520	23	2400	18	2280	15	2160	13	2040	11	1920	9	1800	8
7	3500	117	3360	67	3220	46	3080	34	2940	27	2800	22	2660	18	2520	15	2380	12	2240	11	2100	9
8	4000	133	3840	77	3680	53	3520	39	3360	30	3200	25	3040	20	2880	17	2720	14	2560	12	2400	10
10	5000	167	4800	96	4600	66	4400	49	4200	38	4000	31	3800	26	3600	21	3400	18	3200	15	3000	13
12	6000	200	5760	115	5520	79	5280	59	5040	46	4800	38	4560	30	4320	25	4080	21	3840	18	3600	16
13	6500	216	6240	126	5980	85	5720	63	5460	50	5200	40	4940	33	4680	27	4420	23	4160	20	3900	17
15	7500	250	7200	144	6900	99	6600	73	6300	57	6000	46	5700	38	5400	32	5100	27	4800	23	4500	19
17	8500	283	8160	163	7820	112	7480	83	7140	65	6800	52	6460	43	6120	36	5780	30	5420	26	5100	22
18	9000	300	8640	173	8280	118	7920	88	7560	68	7200	55	6840	45	6500	38	6120	32	5760	27	5400	23
20	10000	333	9600	192	9200	132	8800	98	8400	76	8000	62	7600	51	7200	42	6800	36	6400	30	6000	26
25	12500	416	12000	240	11500	164	11000	122	10500	96	10000	77	9500	64	9000	53	8500	45	8000	38	7500	32
30	15000	500	14400	287	13800	197	13200	146	12600	114	12000	92	11400	76	10800	63	10200	53	9600	46	9000	39

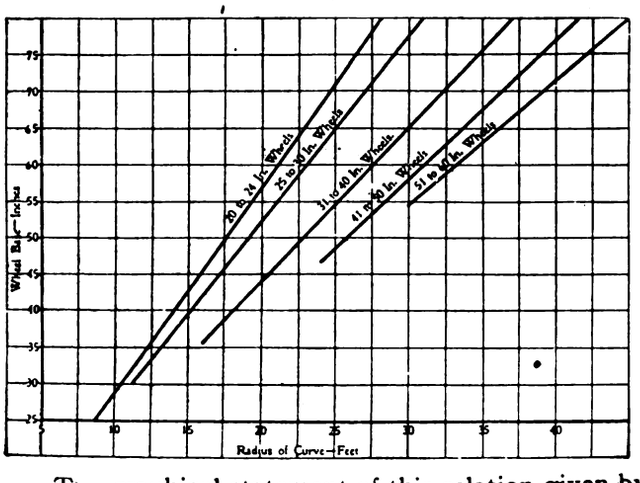
Courtesy Jeffrey Manufacturing Co.

Minimum Sizes of Rails

Minimum sizes of rail recommended for mine locomotives are given in the following table. The values are approximate only, as the proper weight, or size, of rail that should be used is determined by the character of the road bed, the spacing of ties, and general construction. For average conditions in general mine and industrial service, rails of the following minimum sizes are recommended:

Weight of Locomotive in Tons	Weight of Rails in Pounds Per Yard
4 to 6	16
6 to 8	20
8 to 10	25
10 to 13	30
13 to 15	40
15 to 20	50

RELATION OF WHEEL BASE TO RADIUS OF MINIMUM CURVE



The graphical statement of this relation given by the curves is plotted from values obtained from a formula given in the Baldwin Locomotive Works' "Locomotive Data." Experience has shown the values to be safe ones for standard wheel, flange, and truck play. To insure that the curves will give safe results, the same gauge is assumed on curves as on tangent track. If a liberal "spread" is provided in the track at curves, the values of the curves for wheel base may be increased by from 10 to 25 per cent.

Courtesy Westinghouse Electric & M'f'g Co.

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Track and Rail Data

COMPARATIVE TABLE SHOWING PRICE IN GROSS TONS OF 2240 LBS. WITH CORRESPONDING PRICE IN NET TONS OF 2000 LBS. AND PRICE PER CWT.

Gross Ton	Net Ton	Cwt.	Gross Ton	Net Ton	Cwt.
$25.00	$22.32	$1.116	$32.75	$29.24	$1.462
25.25	22.54	1.127	33.00	29.46	1.473
25.50	22.76	1.138	33.25	29.68	1.484
25.75	22.99	1.149	33.50	29.91	1.495
26.00	23.21	1.160	33.75	30.13	1.506
26.25	23.43	1.171	34.00	30.35	1.517
26.50	23.66	1.173	34.25	30.58	1.529
26.75	23.88	1.194	34.50	30.80	1.540
27.00	24.10	1.205	34.75	31.02	1.551
27.25	24.33	1.216	35.00	31.25	1.562
27.50	24.55	1.227	35.25	31.47	1.573
27.75	24.77	1.238	35.50	31.60	1.584
28.00	25.00	1.250	35.75	31.91	1.595
28.25	25.22	1.261	36.00	32.14	1.607
28.50	25.44	1.272	36.25	32.36	1.618
28.75	25.66	1.283	36.50	32.58	1.629
29.00	25.89	1.294	36.75	32.81	1.640
29.25	26.11	1.305	37.00	33.03	1.651
29.50	26.33	1.316	37.25	33.25	1.662
29.75	26.56	1.328	37.50	33.48	1.674
30.00	26.78	1.339	37.75	33.70	1.685
30.25	27.00	1.350	38.00	33.92	1.696
30.50	27.23	1.361	38.25	34.15	1.707
30.75	27.45	1.372	38.50	34.37	1.718
31.00	27.67	1.383	38.75	34.59	1.729
31.25	27.90	1.395	39.00	34.82	1.741
31.50	28.12	1.406	39.25	35.04	1.752
37.75	28.34	1.417	39.50	35.26	1.763
32.00	28.57	1.428	39.75	35.39	1.774
32.25	28.79	1.439	40.00	35.71	1.785
32.50	29.01	1.450			

RAILROAD SPIKES

Size Measured Under Head	Average No. per Keg of 200 Lbs.	Ties Two Feet Between Centers; Four Spikes per Tie Makes per Mile	Rail Used Weight per Yard
5½x9/16	360	5920 lbs. 29⅗ kegs	45 to 100
5 x9/16	405	5230 lbs. 26 kegs	40 to 56
4½x9/16	460	4606 lbs. 23 kegs	35 to 40
5 x½	505	4460 lbs. 21 kegs	
4½x½	535	3960 lbs. 19⅘ kegs	30 to 35
4 x½	605	3515 lbs. 17½ kegs	25 to 35
3½x½	670	3180 lbs. 15⅞ kegs	
4½x7/16	690	3090 lbs. 15½ kegs	20 to 30
4 x7/16	780	2739 lbs. 13⅝ kegs	
4½x⅜	780	2730 lbs. 13⅝ kegs	
3½x7/16	890	2377 lbs. 12 kegs	16 to 25
4 x⅜	1025	2044 lbs. 10⅕ kegs	
3½x⅜	1250	1740 lbs. 8½ kegs	
3 x⅜	1380	1592 lbs. 8 kegs	16 lbs.
2½x⅜	1650	1280 lbs. 6⅖ kegs	12 lbs.

RAILS

Tons per mile required of following weights per yard:

Weight per Yard	Tons 2240 Lbs. per Mile
12 lbs.	18.86
16 lbs.	25.14
20 lbs.	31.53
25 lbs.	39.29
30 lbs.	47.14
35 lbs.	55.00
40 lbs.	62.86
45 lbs.	70.71
50 lbs.	78.56
56 lbs.	88.00
60 lbs.	94.29
65 lbs.	102.14
70 lbs.	110.00
75 lbs.	117.86
80 lbs.	125.71
85 lbs.	133.57
90 lbs.	141.43
100 lbs.	157.14

CROSS TIES
Per Mile

Center to Center	No. Ties
18 inches	3520
21 inches	3017
24 inches	2640
27 inches	2348
30 inches	2113

SPLICE JOINTS
Per Mile

Two bars to each joint

Rails 20 feet long 528 joints
Rails 24 feet long 440 joints
Rails 30 feet long 352 joints
Rails 33 feet long 320 joints

Courtesy W. Va. Rail Co.

PRACTICAL RULE FOR DETERMINING THE ELEVATION OF OUTER RAIL OF CURVE. STANDARD GAGE, 4' 8½"

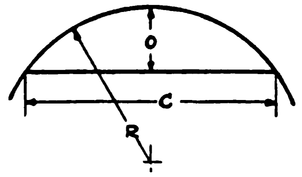
For a train velocity of 10 miles an hour, stretch a 16-foot string, or tape, on the inside of the curve of rail. The distance between the rail and the middle point of the string will be the proper elevation of the outer rail.

For 15 miles an hour use a 24 ft. string
For 20 miles an hour use a 32 ft. string
For 25 miles an hour use a 40 ft. string
For 30 miles an hour use a 48 ft. string

When the track gage is 36 inches:

For 10 miles an hour use a 12½ ft. string
For 15 miles an hour use a 18¾ ft. string
For 20 miles an hour use a 25 ft. string
For 25 miles an hour use a 31¼ ft. string
For 30 miles an hour use a 37½ ft. string

CURVATURE OF TRACK RAILS



Middle Ordinates (O) for Curves of Various Radii (R), on Chords (C) of Various Lengths.

Curvature		Length of Chord (C), Feet					
Radius (R), Feet	Degrees	10	15	20	25	30	50
		Height of Ordinate (O), Inches					
10	....	16.08	40.56	120.00	......	......	......
15	....	10.33	24.24	45.85	80.40	180.00	......
20	286° 38′ 36″	7.69	17.28	32.16	52.55	81.25	......
25	229° 18′ 27″	6.00	13.56	25.10	40.20	60.00	300.00
30	191° 5′ 27″	4.20	10.67	17.53	27.66	40.60	120.00
50	114° 39′ 17″	3.00	6.84	12.12	19.07	27.66	84.00
75	76° 26′ 10″	2.01	4.56	8.04	12.50	18.20	51.56
100	57° 19′ 38″	1.51	3.36	6.03	10.02	13.58	38.20
125	45° 51′ 42″	1.20	2.76	4.81	7.51	10.86	30.32
150	38° 13′ 5″	1.01	2.28	4.01	6.31	9.03	26.00
200	28° 39′ 49″	.77	1.74	3.00	4.69	6.78	18.84
250	22° 55′ 51″	.60	1.44	2.40	3.76	5.41	15.06
500	11° 27′ 56″	.30	.72	1.21	1.87	2.71	7.52
750	7° 38′ 37″	.22	.46	.80	1.32	1.81	5.01
1000	5° 43′ 58″	.16	.34	.60	.94	1.36	3.76

Courtesy Goodman Manufacturing Co.

TRACK BOLTS

Size Bolt	Average No. in Keg of 200 Lbs.	Rail Used Weight per Yard
1⅜x⅜	1790 to 1800	8 lb.
1½x⅜	1775 to 1790	
1½x½	1075 to 1100	12 lb.
1¾x½	965 to 990	16 lb.
1⅞x½	940 to 960	20 lb.
2 x½	830 to 850	
2¼x½	810 to 840	25 lb.
2½x½	790 to 810	
2¼x9/16	650 to 675	30 lb.
2½x⅝	420 to 450	
2½x⅝	420 to 450	35 lb.
3 x⅝	390 to 410	
3 x¾	270 to 280	40 lb.
3½x¾	250 to 260	56 lb.
4 x¾	240 to 250	60 to 75 lb.
4 x⅞	180 to 185	80 to 100 lb.

BEVELS

Rise in Inches on Twelve Inches

Rise, Inches	Angle	Per Cent.	Sine	Cos.	Tan.	Cotan.
¼	1° 11′ 37″	2 1/12	.0208	.9998	.0208	48.0000
½	2° 23′ 8″	4 1/6	.0416	.9991	.0417	24.0000
¾	3° 34′ 35″	6 1/4	.0624	.9981	.0625	16.0000
1	4° 45′ 49″	8 1/3	.0830	.9965	.0833	12.0000
1¼	5° 56′ 49″	10 5/12	.1036	.9946	.1042	9.6020
1½	7° 7′ 30″	12 1/2	.1240	.9923	.1250	8.0000
1¾	8° 17′ 50″	14 7/12	.1443	.9895	.1458	6.8548
2	9° 27′ 44″	16 2/3	.1644	.9864	.1667	6.0000
2¼	10° 37′ 11″	18 3/4	.1843	.9829	.1875	5.3333
2½	11° 46′ 6″	20 5/6	.2039	.9790	.2083	4.8009
2¾	12° 54′ 27″	22 11/12	.2234	.9747	.2292	4.3630
3	14° 2′ 10″	25	.2425	.9702	.2500	4.0000

FROG AND SWITCH DATA

Frog No.	Spread Per Foot	Frog Angle	Radius Curve in Feet					Switch Points Suitable Lengths
			Gauge 3′ 0″	Gauge 3′ 6″	Gauge 3′ 8″	Gauge 4′ 0″	Gauge 4′ 8½″	
1	12″	53° 0′	6.00	7.00	7.33	8.00	9.41	4′ 0″
1¼	9⅝″	43° 40′	9.36	10.93	11.11	12.50	14.68	4′ 0″
1½	8″	36° 52′	13.50	15.75	16.50	18.00	21.19	4′ 0″
1¾	6⅞″	31° 53′	18.31	21.44	22.44	24.42	28.74	4′ 0″
2	6″	28° 04′	24.00	28.00	29.33	32.00	37.65	5′ 0″
2¼	5 11/32″	25° 08′	30.37	35.44	37.12	40.50	47.67	5′ 0″
2½	4 13/16″	22° 37′	37.50	43.75	45.83	50.00	58.85	5′ 0″
2¾	3⅞″	20° 37′	45.37	52.94	55.44	60.55	71.71	5′ 0″
3	4″	18° 55′	54.00	63.00	66.00	72.00	84.75	7′ 0″
3¼	3 11/16″	17° 30′	63.37	73.94	77.37	84.50	99.46	7′ 0″
3½	3 15/32″	16° 16′	73.50	85.75	90.00	98.00	115.27	7′ 0″
3¾	3 3/16″	15° 11′	84.37	98.44	107.21	116.96	137.57	7′ 0″
4	3″	14° 15′	96.00	112.00	117.33	128.00	150.66	7′ 0″
4¼	2 27/32″	13° 26′	108.37	126.43	132.45	144.50	169.79	7′ 0″
4½	2 21/32″	12° 41′	121.50	141.75	148.50	162.00	190.60	10′ 0″
5	2 13/32″	11° 25′	150.00	175.00	183.33	200.00	235.40	10′ 0″

Courtesy Helmick Fdy. & Machine Co.

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ELEVATION OF RAIL ON CURVES

The superelevation of the outer rail to allow for the centrifugal force of running cars at a velocity of 6 miles per hour, and a 30-inch gage track, should be as follows:

For a 40 foot radius curve	1¾ inch
For a 50 foot radius curve	1½ inch
For a 60 foot radius curve	1¼ inch
For a 80 foot radius curve	1 inch
For a 100 foot radius curve	¾ inch
For a 150 foot radius curve	½ inch
For a 200 foot radius curve	⅜ inch

This superelevation varies directly as the gage, so that if the gage is 40 inches the superelevation would be 40/30, or 4/3, times as great as that shown in the table.

The superelevation also varies as the square of the velocity; thus, if the velocity is 12 miles per hour, instead of 6 miles per hour, for which speed the table was computed, the superelevation would be $\left(\frac{12}{6}\right)^2$, or four times as great.

From "Location and Construction of Mine Tracks," by J. McCrystle.

SPECIMEN FORM SHEET FOR TRACK MATERIAL

(Information Desired by Manufacturers)

Give the following data when sending inquiries for track material:

Height of rail.....

Weight of rail.....

Distance from end of rail to center of first splice hole .....

Distance from center of first splice hole to center of second splice hole.....

Angle in degrees and minutes or number of Frog .....

Length of switch points.....

Gauge of track .....

EXPANSION OF RAILS

Where rails are laid underground, the small variations in the temperature will not require any allowance at the joints for expansion; when they are laid on the surface, however, the space left for the expansion of 30-foot rails should be as follows:

Temperature when rail is laid	Space to be allowed for expansion
24 deg. and less	¼ inch
25 deg. to 49 deg.	3/16 inch
50 deg. to 74 deg.	⅛ inch
75 deg. to 94 deg.	1/16 inch
95 deg. and over	0

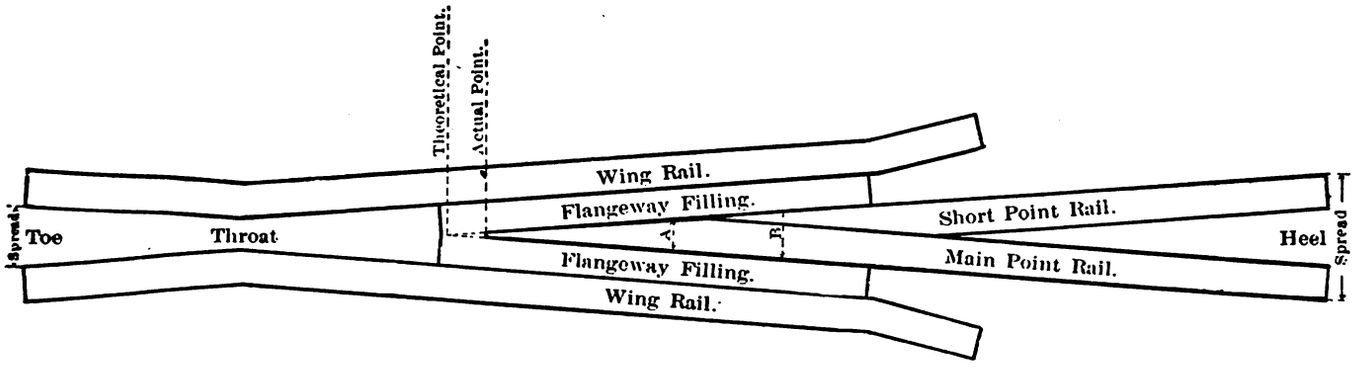
From "Location and Construction of Mine Tracks," by J. McCrystle.

SIMPLE RULES FOR MEASURING FROGS AND TURN-OUTS

To Find the Number of a Frog

The number of frog is the same as the number of feet ((measured along center line of frog) in which it spreads one foot, or the number of inches in which it spreads one inch. For instance, a No. 10 frog spreads one inch in ten inches of length.

Then, to find the number of a frog, place a rule on the head of the point rails where the point is two inches wide from gauge side to gauge side, mark that place as at A, then move the rule back towards the heel of the frog until the head measures three inches wide, and mark this place as at B. The distance in inches between the two marks is the number of the frog. As a check upon this measure the spread of the frog at heel (which is the distance from gauge side to gauge side of the head of the rails) and the spread of the frog at toe; add the two spreads together and divide the length over all of the frog by the sum; the result is the number of the frog.



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GEO. D. WHITCOMB COMPANY

Main Office and Works

ROCHELLE, ILLINOIS, U. S. A.

Sales Representatives in All Principal Cities

Trolley Locomotives

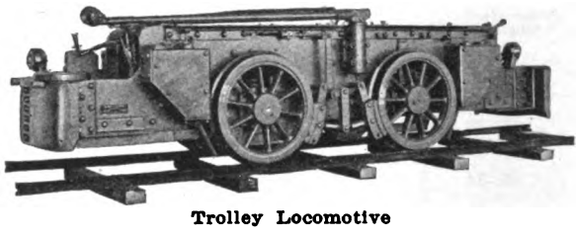
Products

Trolley Locomotives from 3-ton to 20-ton operating either with or without crab reel. Made in all gauges from 18″ to 60″. Storage Battery Locomotives, see Pages 340 and 341. Gasoline Locomotives see Pages 344 and 345.

Construction

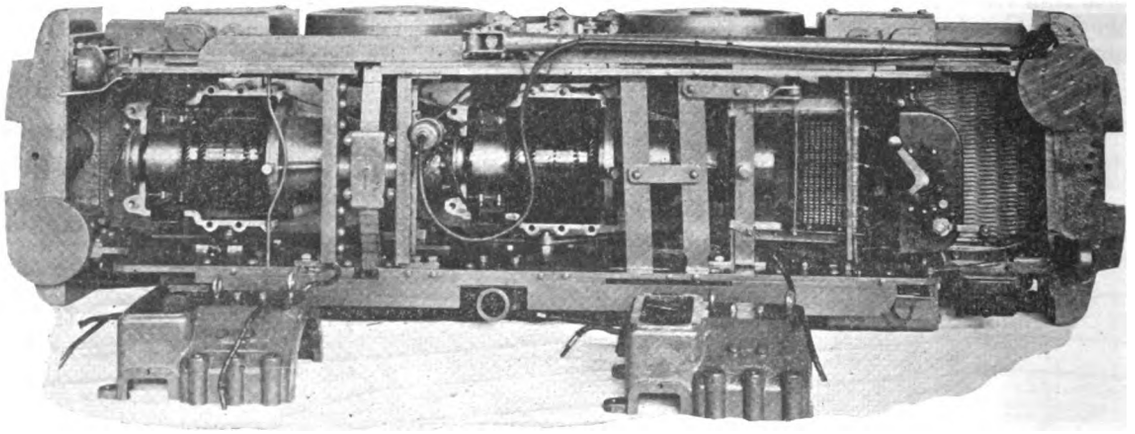
THE MOTOR—Without question, the greatest advance in vehicle motor design has been accomplished in this type of locomotive. Realizing that the motor is the heart of the unit, our engineers made a most exhaustive study to develop a power plant that would respond quickly and steadily. This they have accomplished. The case of this motor is of Electric Dynamo Steel, made in two sections to allow quick accessibility. The field coils, constructed of the best of materials, are secured to the case by cap screws, thus allowing easy replacement. The brush holders are of heavy bronze and are, because of inspection plates located on the case at each point of brush contact, easily reached.

The brushes are of carbon of standard design and because of the brush holder design, are easily removable. The armature is of the Ironclad type, mounted at both ends on oversize ball bearings. The core is of laminated steel construction. The coils, made of flat ribbon wire, are hung below the face of the core and are imbedded and wedged below the surface. The commutator is of drop-forged copper with the best of mica insulation, slightly undercut to allow free brush contact. Particular note should be taken of the commutator size. This increase in area, together with the additional brush contact, gives this motor a very favorable characteristic,—namely, low temperature. This is found



Trolley Locomotive

of great advantage, because of the absence of those faults accompanying an over-heated commutator. Of no less importance is complete accessibility. By removing the top section of the case, the armature may be lifted out without disturbing other parts of the locomotive, or, if desired, the entire motor can be taken out in a very short time, likewise without disturbing other parts of the locomotive. Perhaps the greatest advantage of this motor is its higher speed than other designs. The



Top of Trolley Pole Locomotive With Motor Housings Removed

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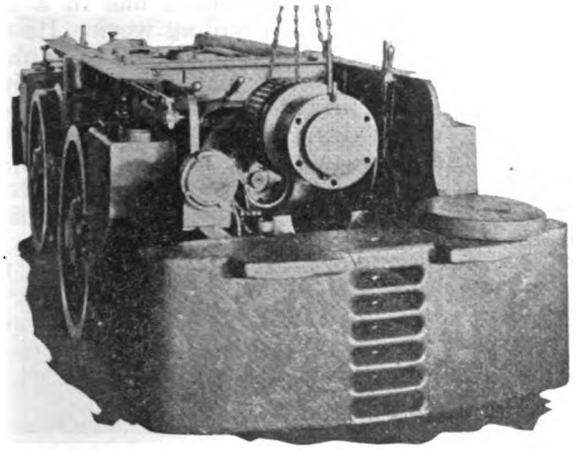
additional power and constant torque thus acquired is of no mean advantage in operation. The fact that this motor is built and tested in our own shops under the most rigid inspection, gives it the stamp of quality.

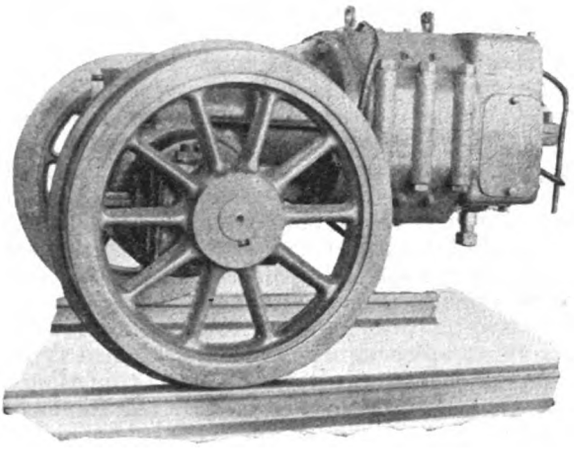
WORM GEAR AND WORM WHEEL—The drive from the motor is direct from the armature to the worm gear by means of a tongue and groove coupling. This worm gear is so mounted on twin or duplex type ball bearings that any thrust load is immediately taken care of. In direct contact with the worm gear and located on the axle is a bronze worm wheel. These units are enclosed in a steel case, carried on the axle by means of heavy duty ball bearings, the result being that the worm gear and worm wheel are always in proper relation, thus preventing sag and undue wear. This case is constantly filled with oil, and arrangement is made for re-oiling without disturbing or removing any parts of the locomotive. The fact that the power plant or motor and the worm drive are of unit construction gives a transmission efficiency of over 90%. Such efficiency is possible only in the Whitcomb Worm Drive construction.

AXLES AND WHEELS—The axles are of chrome vanadium steel and are carried in journal boxes on heavy duty bronze bearings. The wheels are of large diameter with cast centers and steel tires. The use of large diameter wheels, made possible by the high speed motor and reduction through the worm gear and wheel, gives an unusual track clearance.



Accessibility of Motor Showing Armature Being Removed

FRAMES AND BUMPERS—The frames are built of universal mill sheets and structural shapes, having an average ultimate tensile strength of 60,000 pounds per square inch. The bumpers are of heavy casting with pockets allowing variable draw bar heights. The chassis is suspended on the axle or journal boxes by means of coil springs on the driving end and on the other end an equalizer spring held centrally on the chassis by a king bolt, with each end bearing on the journal box. The result of this three-point suspension is constant rail contact, as it allows the locomotive to run over uneven track, taking up the tilting through this method of suspension.



Wheels and Motor

SANDER MECHANISM—Proper provision is made for sanding any of the wheels from the operator's seat.

CONTROLLER—The controller is of the standard drum type, with a removable case, allowing admission to the contacts and fingers.

TROLLEY POLE—The trolley pole is of standard design supported in an improved type base which is so designed as to prevent binding or jumping of the trolley pole.

ELECTRICAL FITTINGS—Every connection is made by heavy copper socket terminals, which allow quick and easy connection. The wiring is all heavily insulated and so placed as to be conveniently inspected. Each locomotive is equipped with headlights of the indestructible type.

SPECIFICATIONS OF EIGHT-TON DOUBLE MOTOR DOUBLE WORM TROLLEY LOCOMOTIVE

Gauge	24″	36″	40″	44″	48″
Length	158″	158″	158″	158″	158″
Width	48″	60″	48″	51″	55″
Height Over Frame	35″	35″	35″	35″	35″
Height Trolley Down	40″	40″	40″	40″	40″
Wheel Base	50″	50″	50″	50″	50″
Wheels	24″	24″	24″	24″	24″

Draw Bar Height—All Gauges—5½″, 8″, 10½″, 13″, 15½″, 18″.
Dimensions on any size up to 15 ton gladly furnished on request.

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GENERAL ELECTRIC COMPANY

General Office: SCHENECTADY, N. Y.

Sales Representatives in All Principal Cities
For Complete List of Offices, See Page 239

Manufacturer of

Complete Electrical Equipment

Products

For description of other products made by the General Electric Company not shown in the Haulage Section see the Electrical Equipment Section, pages 239 to 247.

Mine Haulage Locomotives

The General Electric Company has been engaged in the manufacture of mine locomotives for the past thirty years, and as evidence of durable construction can point to some of the first locotives built, which are still in active service. This is proof that the Company appreciates the severe conditions of mine service, and builds locomotives that will stand up under most trying conditions.

General Construction

The two-motor locomotive for sizes under 25 tons has come to be recognized as the standard type for mine work. There are two forms of this type, the selection of which is determined by the mine conditions. One has the wheels placed inside the frames and the other has the wheels outside the frames.

G-E Mining Locomotive, Hollister Mining Company, Crystal Falls, Mich.

The outside frame type allows the maximum space between the wheels for motors and other equipment and gives more cab space for the motorman. With the outside frame trolley type locomotives the weight is supported from the journal boxes by substantial semi-elliptic leaf springs. An equalizer bar between the springs transmits the change in wheel load due to uneven track. This reduces the chances for derailment and increases the available traction by having the weight more equally distributed on all wheels. The riding qualities are improved, which reduces wear on the track and adds to the comfort of the motorman. With this construction the high clearance of the frame permits access to the lower part of the wheel, rerailing devices may be put into position, and the locomotive readily put back on the track.

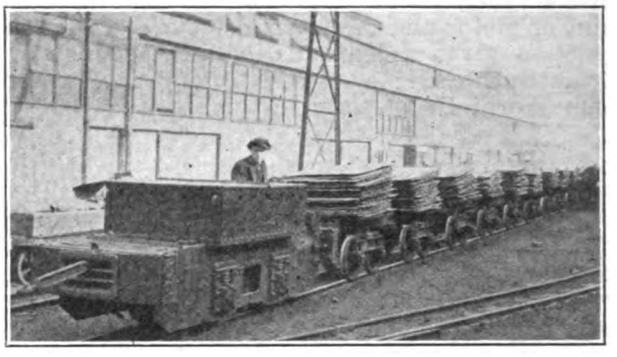
The inside frame finds application particularly where the side clearance in the mine will not permit the width of the outside frame type.

Bulletin 64202 describes more in detail these constructional features of trolley type units for main line haulage.

Electric Industrial Locomotives

For work in and about smelting and refining plants and mills and quarries, electric locomotives have come into extensive use. For hauling raw materials or for convenient handling of ladle cars, etc., either the trolley or third rail type is suitable. In some plants the storage battery locomotive is used for hauling the finished products to the storage sheds and for miscellaneous transportation.

G-E Locomotives of all three types are represented in many such installations. Bulletin 44251 describes and illustrates units in service in several different industries, including steel plants, ore docks, smelters and refineries and quarries.



G-E Storage Battery Locomotive, Baltimore Copper Smelting and Rolling Company, Baltimore, Md.

Storage Battery Locomotives

The storage battery locomotive has in a few years won a lasting place in mining work. Its use is advocated wherever the conditions of haulage are favorable. G-E Storage Battery Locomotives were among the first in this field, and their success in meeting various conditions has demonstrated their correctness in design and principle. The opportunity is solicted for G-E engineers to advise with you on the selection of this type of locomotive. (Bulletin 64201.)

Every G-E locomotive is designed to meet the requirements and necessitates engineering recommendations. The following tabulated data, applying to commonly used types, will give an idea of the specifications on storage battery units which have been built.

Approx. Wt. with Battery, Tons	Type	No. of Motors	Gauge	DBP, Lbs.	MPH at Rated DBP	Battery Capacity, K.W.H.	Brakes
5	LSB-2C8	2	56½	3200	3½	48	Hand
10	LSB-2C10	2	56½	3600	4½	54	Hand
15	LSB-2C15	2	56½	4800	5	67	Hand, Straight Air
25	LSB-404-E50	4	56½	9000	5	134	Hand, Straight Air
40	LSB-404-E80	4	56½	14500	5½	216	Hand, Straight Air

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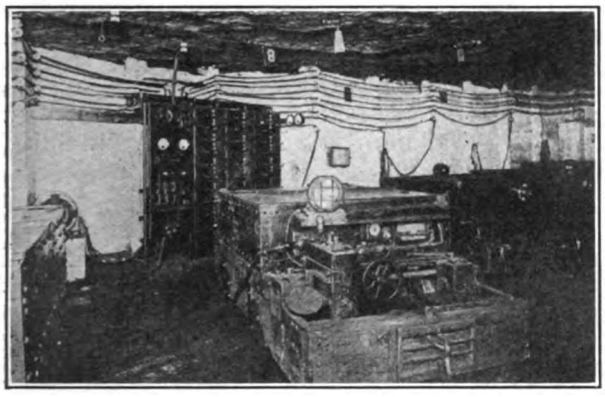
Battery Charging Equipment

Storage battery charging equipment is, of course, a necessary accessory in connection with the operation of storage battery locomotives. This Company manufactures battery charging apparatus of all types. Equipment for mine use is usually motor generator outfits with charging panels.

Individual charging motor generator sets are designed to regulate the current and taper the charge of a single battery. These sets can be installed for operation in multiple, the same as a 2-circuit generator and panel.

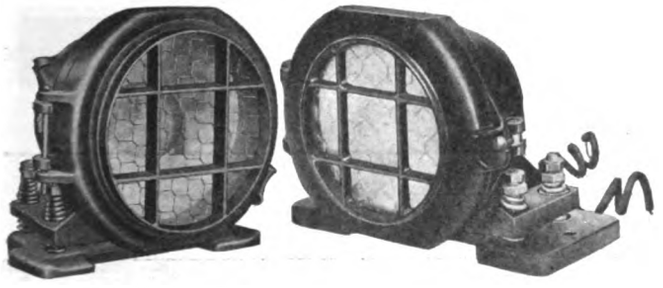


Battery Charging Set and Panel in Operation

Motor-generator sets for simultaneously charging two or more batteries in multiple are made for operation from either 2- or 3-phase, 60 cycle circuits in standard voltages. Special sets for operation on other voltages or for operation on direct current are also made. The control panels for these sets are necessarily different from those for individual battery charging sets in order that different degrees of discharge may be properly handled. (Bulletin Y-1364.)

Mine Locomotive Headlights

The headlight of a mine locomotive is an important part of its equipment. It must be so designed that the spread of light is over a wide range; it must be powerful enough to penetrate fog, dust and smoke, and "pick up" objects at a considerable distance to give the operator sufficient time to bring the locomotive to a stop without jar or shock when necessary to avoid accidents; it must be dust-proof and moisture-proof; and it must be protected against falling objects and rough handling incident to mine work. The construction of G-E mine locomotive headlights is such that they meet the above requirements.



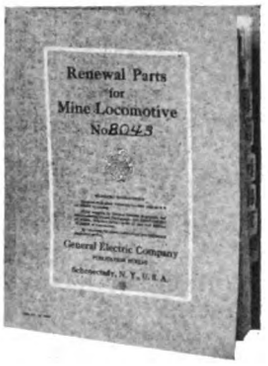
Form H-4 Mining Type Incandescent Headlight

Form H-3 Mine Type Headlight

The Form H3 medium-powered headlight, designed for small haulage locomotives, is usually equipped with a 36-watt incandescent lamp with which its fixed focus places the pick-up distance at from 250 to 300 feet. Its specially-prepared glass reflector retains reflecting power indefinitely and does not become scratched and tarnished. Shock absorbers guarantee long life to bulbs. (Booklet B-3635.)

Renewal Parts Service

The General Electric Company maintains an exceptional repair part service for all mining apparatus. In the case of mine locomotives this service is expedited by the use of a special renewal parts catalog compiled for each locomotive. These catalogs contain all the information required for the correct ordering of any repair part. Delays incident to possible misunderstanding of orders are thus eliminated.



One of these catalogs is furnished with each locomotive, and extra copies are gladly made up for persons in the customer's organization who are charged with the upkeep of equipment.

Railway Line Material

This Company offers mining companies a complete line of devices used in the construction of trolley systems and track return. This includes pole brackets, suspensions and clamps of various types, strain and feeder insulators, splicing sleeves, trolley frogs and crossings, section switches and insulators, turn buckles, rail bonds, bonding tools, etc.

Special forms of these devices have been developed to meet the special conditions of mine properties, such as mine clamps, which, at no sacrifice of holding power, are designed to save headroom. The Form W clamp is designed to take either grooved or Figure 8 trolley wire or round feeder wire, so that a feeder supplying current to electric mining machinery can be replaced later with trolley wire, using the same clamps.

Electric oven sherardizing, a special G-E process, is the standard finish for all iron and steel parts. Japan finish can be furnished for use where devices are subject to the deteriorating effects of acids.

Rail Bonds—G-E Welded Bonds have steel faces expertly arc welded in the factory to drop forged copper terminals. Thus a track welder merely makes the perfect steel weld he is used to, and the bond becomes an integral part of the track—wiping out the joint. Welding equipment can also be furnished.

The Company will gladly submit recommendations showing how best to meet any bonding conditions. Submit your problem to the nearest G-E Sales Office.

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THE JEFFREY MANUFACTURING COMPANY

959-99 North Fourth Street, COLUMBUS, OHIO

TYPE WIRE OFFICES

New York City, Room 2008, 30 Church St. Phone Cortlandt 5417 or Cortlandt 7241

Pittsburgh, Pa., 2111 Farmers Bank Bldg. Phone Grant 407

Chicago, Ill., 858 McCormick Bldg. Phone Harrison 8008

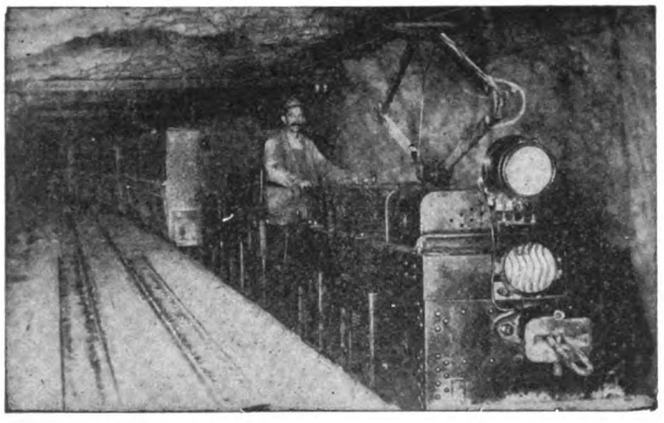
Telephone any of the type-wire offices mentioned above, and your request for Jeffrey Products or Service will be at once typed over our own private wire to Columbus, and the information given you quickly and without extra cost

Products for Metal Mines, Mills, Smelters, Quarries, Etc.

Locomotives—Trolley, Storage Battery, Combination; Dryers—Coal, Concentrate, Ore, Rock, Sand; Chain and Cable Car Hauls; Skip Hoists; Chutes; Chute Gates; Gears and Pinions—Mitre, Bevel and Spur; Sand and Gravel Handling Equipment; Loaders — Wagon, Truck, Portable; Crushers; Crusher Rolls; Crushers and Grinders; Pulverizers, Swing Hammer; Drills—Air, Steam, Electric (Rock); Coaling Station Equipment; Loading Booms; Loading Machines; Quarry Machinery; Rolls and Teeth, Crushing; Balls—Grinding; Castings—Malleable Iron; Linings—Ball and Tube Mills (Metal and Silica); Screens—Shaking; Sprockets; Storage Systems—Coal; Tables—Picking.

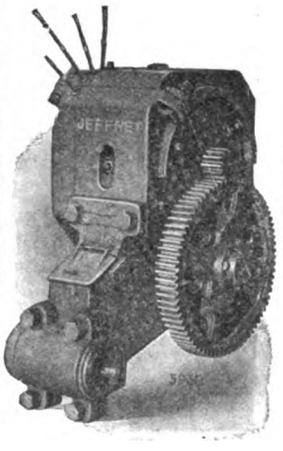
Jeffrey Electric Locomotives for Metal Mines

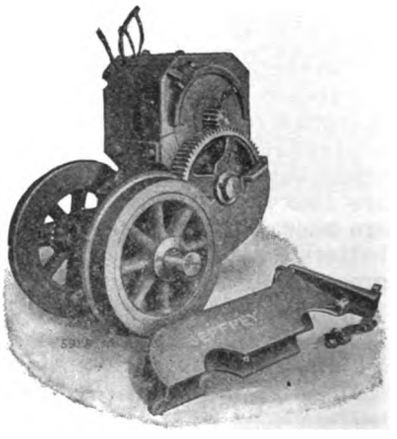
The Jeffrey Locomotives illustrated and described on this page are designed and built to meet the conditions of heavy haulage service for handling ore, rock, or other material on narrow gauge tracks in metal mines.



Tandem Unit of Jeffrey 6-Ton Locomotive installed in the mines of the Arizona Copper Company, Morenci, Arizona. Each unit equipped with two 30 H. P. motors and airbrakes. Can be built for 18″ gauge or wider.

Lower Illustration
30 H. P. motor mounted on wheels and axles.





Showing method of mounting motor for narrow gauge track.

30-H. P. Motor, mounted on special cast steel bracket with intermediate gear between armature pinion and gear on the axle, permits of large motor capacity for 18″ gauge.

DIMENSIONS

Weight Tons	Number of Motors	H. P. Each Motor	DRAW BAR PULL				WIDTH OVERALL (Gauges)							Length Over Frams	Height Over All	Min. Height Trolley Wire	Wheel Base	Diam. Wheels	Diam. Axles
			C. I. Wheels		Steel Wheels		18″ to 20″	20½″ to 23″	24″ to 30″	30½″ to 36″	36½″ to 42″	42½″ to 48″	56½″						
			Rated	Starting	Rated	Starting													
4	2	20	1600	2000	2000	2400	41½″	44½″						11′7″	52″	54″	40″	24″	3¼″
6	2	30	2400	3000	3000	3600	41½″	44½″						11′7″	55″	59″	42″	26″	4 ″
4	2	20	1600	2000	2000	2400			44″	50″	56″	62″	70½″	9′5″	36″	38″	33″	24″	3¼″
6	2	30	2400	3000	3000	3600			46″	52″	58″	64″	72½″	10′2″	40″ 39″	42″ 41″	40″ 40″	28″ 26″	4 ″

To get length over all add 30″ to length of frame for couplers or special hitchings.
To get length over all add 16″ to length of frame for small cast bumpers.

Where haulage conditions require a greater weight of locomotive than the 4 or 6 ton size on narrow gauges, it is necessary to connect two locomotives in tandem, making either an 8-ton unit or a 12-ton unit. These locomotives can be equipped with straight air brake equipments where haulage conditions require it.

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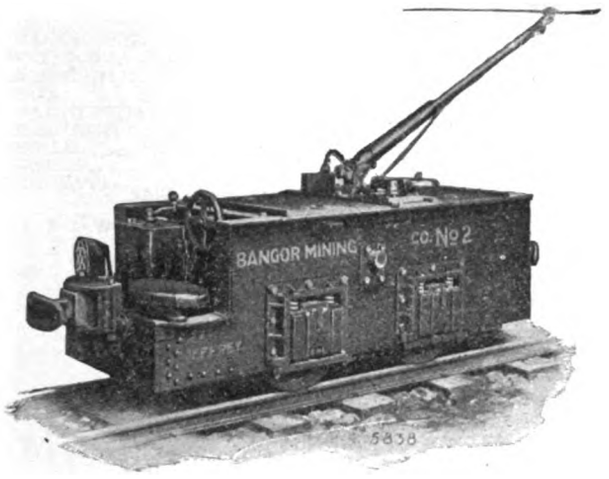
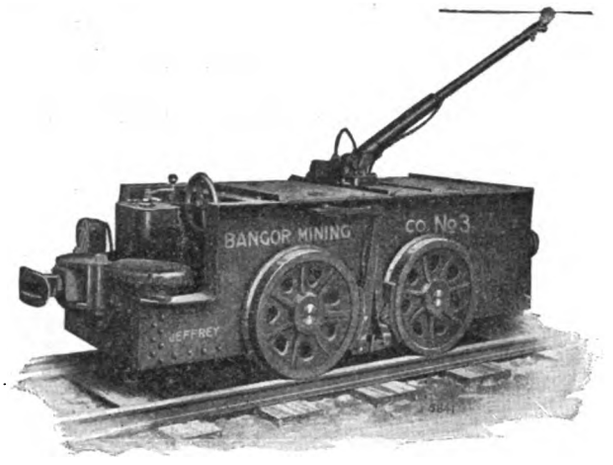
Jeffrey Locomotives For Metal Mines



4-Ton Electric Locomotive. Built to operate on 24″ gauge with inside wheels or 36″ with outside wheels.



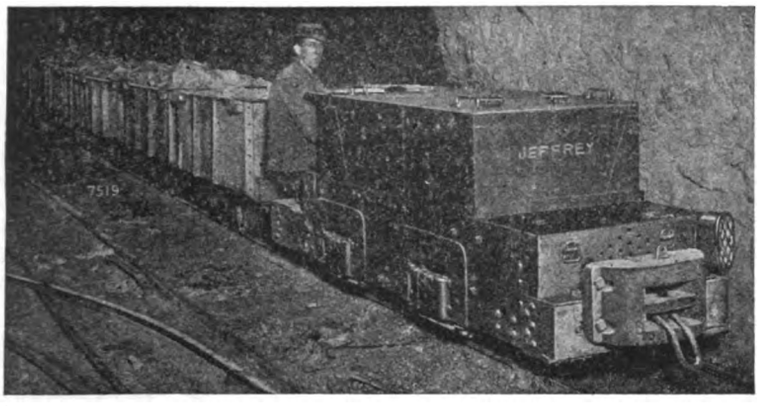
4-Ton Electric Locomotive. Built to operate on 36″ gauge outside wheels or 24″ gauge inside wheels.

To change from one gauge to the other requires new wheels and axles and journal boxes only.

DIMENSIONS

Weight Tons	Number of Motors	H. P. Each Motor	DRAW BAR PULL				WIDTH		Length Over Frame	Height Over All	Min. Height Trolley Wire	Wheel Base	Diam. Wheels	Diam. Axles
			C. I. Wheels		Steel Wheels		18″ to 20″ Gauge	20½″ to 23″ Gauge						
			Rated	Starting	Rated	Starting								
4	2	20	1600	2000	2000	2400	41″	42″	8′-4″	40″	42″	33″	24″	3¼″

Jeffrey Storage Battery Locomotives for Metal Mines Furnished for Gauges from 18″ to 42″



Jeffrey 6000 Lb. Chassis Storage Battery Locomotive Hauling Ore

The Jeffrey Storage Battery Locomotives built for narrow gauges are equipped with a motor known as M.H.108, mounted with the armature shaft lengthwise of the locomotive and drives the axle directly through single reduction worm and worm wheel gearing.

This arrangement permits of a larger and more efficient motor equipment on narrow gauges than would be possible with a motor mounted between the wheels with the armature shaft cross-wise of the locomotive. The worm wheel has a high mechanical efficiency, is noiseless and permits the locomotive to coast with perfect ease.

DIMENSIONS STORAGE BATTERY LOCOMOTIVES 1000 LBS. DRAW-BAR PULL AT 3.5 M.P.H. Inside Wheels

Weight of Chassis	Battery Equipment	Listed Weight of Battery	BATTERY CAPACITY		WIDTH OF LOCOMOTIVE					Width of Battery Box	Length Over Bumpers	Height of Frame Above Rail	Height of Battery Box Above Rail	Wheel Base	Diameter of Wheels	Diameter of Axles	Type and Class of Motors	No. of Motors	Ton Miles Level Track
			K. W. Hours	Ampere Hours	18″ to 23½″ Gauge	24½″ to 29½″ Gauge	30″ to 35½″ Gauge	36″ to 42″ Gauge	Above 42″ Gauge, Add										
6000	80 A-4	1230	14.4	150	38½	44½	50½	57	15	30½	11′6″	25	43½	36	18	3¼	M.H. 108	2	180
6000	80 A-5	1450	18	187.5	38½	44½	50½	57	15	35½	11′6″	25	43½	36	18	3¼	M.H. 108	2	220
6000	80 A-6	1670	21.6	225	39½	44½	50½	57	15	39½	11′6″	25	43½	36	18	3¼	M.H. 108	2	270
6000	48 MV-9	1700	12.86	136	39	44½	50½	57	15	31¾	11′0″	25	44½	36	18	3¼	M.H. 108	2	160
6000	48 MV-11	1890	16.08	170	45¼	45¼	50½	57	15	45¼	11′0″	25	44½	36	18	3¼	M.H. 108	2	200
6000	48 MV-13	2460	19.29	204	45¼	45¼	50½	57	15	45¼	11′0″	25	44½	36	18	3¼	M.H. 108	2	240
6000	48 MV-15	2810	22.51	238	45¼	45¼	50½	57	15	45¼	11′6″	25	44½	40	18	3¼	M.H. 108	2	280
6000	48 WML-11	1645	14.6	155	45¼	45½	50½	57	15	45¼	11′0″	25	44½	36	18	3¼	M.H. 108	2	195
6000	48 WML-13	1920	17.6	186	45¼	45¼	50½	57	15	45¼	11′0″	25	44½	36	18	3¼	M.H. 108	2	220
6000	48 WML-15	2185	20.5	217	45¼	45¼	50½	57	15	45¼	11′6″	25	44½	40	18	3¼	M.H. 108	2	256

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Halsted and 48th Sts., CHICAGO, ILLS.

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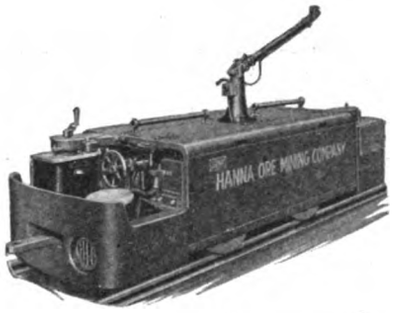
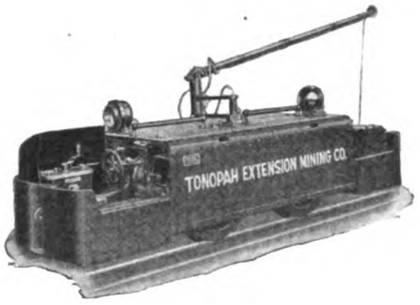
TOKIO, JAPAN—24 Unemecho Kyobashi-ku

Haulage and Tramming Locomotives





Products

Electric Locomotives of the following types:

Trolley.
Reel-and-Trolley.
Storage Battery.
Trolley and Battery.

There's a Goodman locomotive for every operative condition.

The range of types, sizes, equipment, etc., is so great that adequate specifications covering all requirements are impossible here.

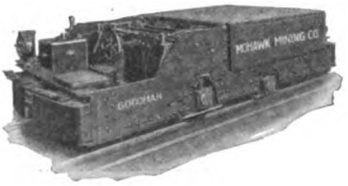
We make recommendations only on analysis of conditions, and we quote only on what we know will give satisfactory service.

Locomotives for gauges 18" and wider.

Trolley locomotives with electric cable reels for avoiding the stringing of trolley wire into places where its presence is undesirable or its maintenance difficult.

Small-dimension locomotives for transfer from level to level.

Other special provisions for special situations.



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AMERICAN STEEL & WIRE CO.

SALES OFFICES

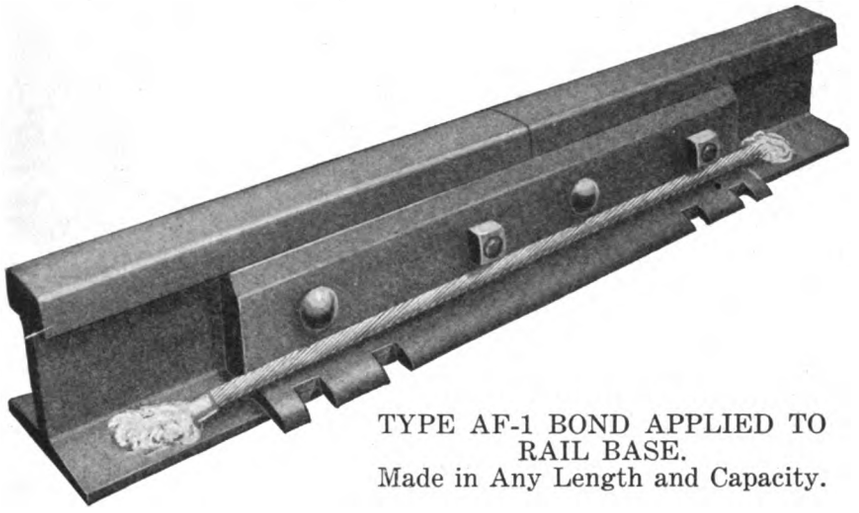
CHICAGO.....208 So. La Salle Street
NEW YORK.....30 Church Street
WORCESTER.....94 Grove Street
BOSTON.....185 Franklin Street
PHILADELPHIA.....Widener Building
PITTSBURGH.....Frick Building
BUFFALO.....337 Washington Street
DETROIT.....Foot of First Street
CINCINNATI.....Union Trust Building
CLEVELAND.....Western Reserve Building
BALTIMORE.....32 So. Charles Street
WILKES-BARRE, PA....Miners Bank Building
ST. LOUIS—Liberty Central Trust Company Bldg.
KANSAS CITY.....417 Grand Avenue
ST. PAUL-MINNEAPOLIS.Pioneer Bldg., St. Paul
OKLAHOMA CITY...1st National Bank Building
BIRMINGHAM, ALA.....Brown-Marx Building
DENVER.....1st National Bank Building
SALT LAKE CITY.....Walker Bank Building

Export Representative: U. S. Steel Products Co., New York
Pacific Coast Representative: U. S. Steel Products Company
San Francisco Los Angeles Portland Seattle

ARC WELD RAIL BONDS

Products

We stock Bonds, Welding Machines, Arc-Welding Electrodes, Welding Masks and Shields and all necessary equipment ready for immediate shipment.

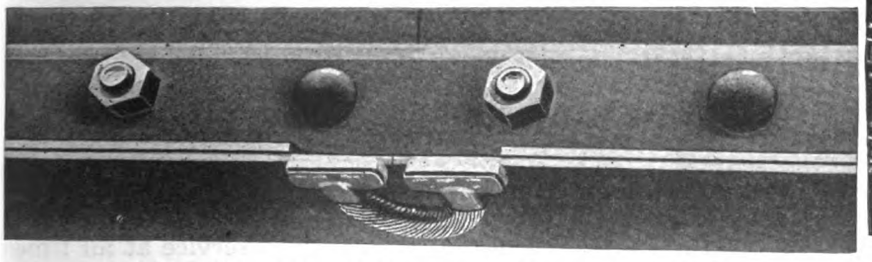


TYPE AF-1 BOND APPLIED TO RAIL BASE.
Made in Any Length and Capacity.

AS & W STEEL TERMINAL BONDS

Type AC Bond for application to rail base where fish plates are used. This bond is short, usually furnished 10½″ in length in sizes 3/0 and 4/0.

These welded terminals cannot corrode or become loose. They are easily installed by a small portable welding machine weighing but 45 lbs. and having no moving parts. This machine may be used for any welding work around the mine.



Type AA-5 Bond Applied Under Base of Rail.

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The Atlas Car & Manufacturing Company

Factories and General Offices

CLEVELAND, OHIO, U. S. A.

1100 to 1150 Ivanhoe Road

Branch Offices Located at

Philadelphia.....20 South 15th St.
New York.....Woolworth Bldg.
Pittsburgh...Benedum-Trees Bldg.; House Bldg.
Ironton, O.....2509 South 4th St.
Chicago.....53 W. Jackson Blvd.
Birmingham, Ala.....419 American Trust Bldg.
San Francisco.....Merchants Exchange
Los Angeles.....San Fernando Bldg.

Engineers—Manufacturers

Products

Storage Battery Locomotives; Trolley Locomotives; Combination Locomotives; Cars for every purpose; Skips; Dumping Buckets; Mine Cages; Hot Metal Cars; Ingot Cars. Also Small Gasoline Locomotives.

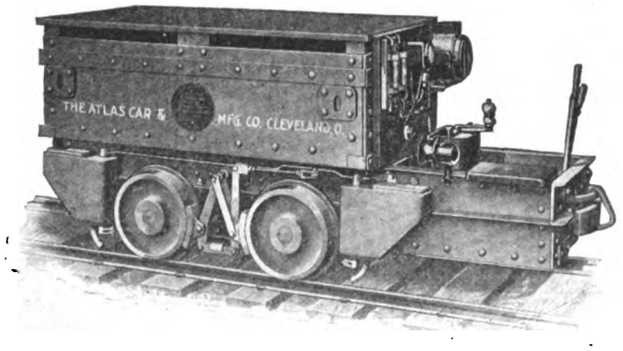
Storage Battery Locomotives

Atlas Storage Battery Locomotives are made in five standard types to suit all usual conditions of haulage, but special machines can be designed and built to meet special requirements.

Type C Locomotive

This type is suitable for light hauls and narrow track gauges. It is the most compact storage battery locomotive on the market. It is built in 2 and 2½-ton sizes for any track gauge wider than 18". Machine is 37" high.

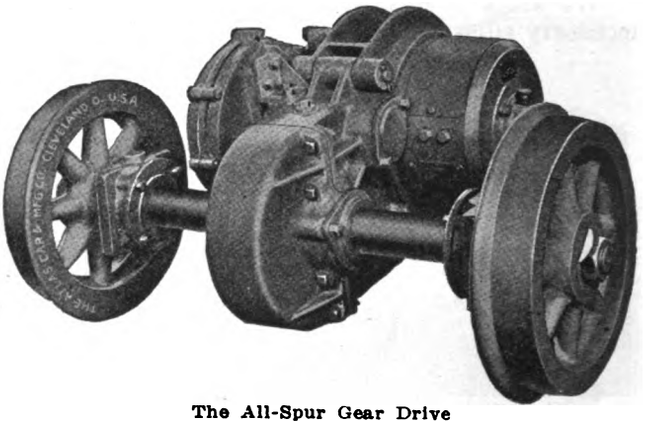
Machine is driven by means of one motor which is mounted in a three point equalizing support directly connected by means of a flexible joint to a gear reduction mounted on ball bearings in an oil-tight housing. The reduction from the gear to the axle is by means of chains.



Type C Locomotive

Drive Unit

The Atlas Drive Unit has the axle gears mounted between the bearings in a heavy housing which protects the gears and provides adequate lubrication for the gears and bearings. The gears are held in proper mesh at all times, and as all bearings are ball bearings, this drive is highly efficient and has earned the slogan, "The Drive You Cannot Break."

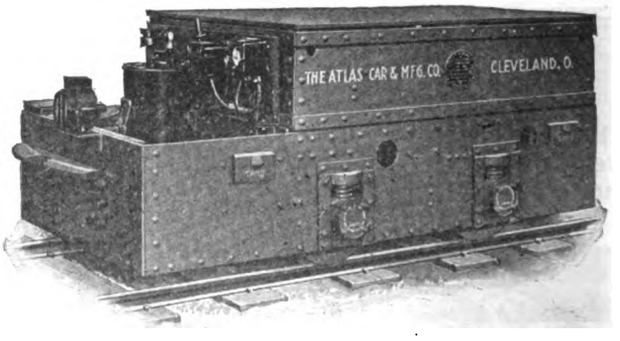


The All-Spur Gear Drive

Type A Locomotive

Type A Locomotive is of heavy type and is built in all sizes from 3 to 10 tons. As the frame is outside of the wheels, the machine can be adapted to narrow track gauges. This machine is 45" high.

Type A Locomotive has two driving motors, one geared to each axle by means of spur gears mounted on full ball bearings. The gears are of the Tool Steel brand and the drive housing is patented.



Type A Locomotive

Engineering Service

Atlas engineers are at your service at all times to assist you to determine exactly what type of locomotive is most suitable for your conditions.

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THE ATLAS CAR & MANUFACTURING CO.
Cleveland, Ohio

Manufacturers of Industrial Railway Cars and Accessories for the economical handling of material in and around mills, mines and quarries.

Cars of various types and sizes of standard or special designs to suit the particular conditions for which they are required. Trolley or Storage Battery Driven Cars can be supplied if preferred.

Dumping Buckets of various descriptions, in dimensions and capacities to suit specifications.

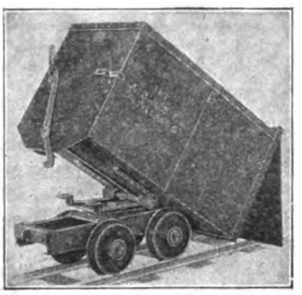
Cages of several styles. Drawings and specifications furnished upon request.

Track Equipment, consisting of Turntables, Portable Track, Switches, Turnouts, and Crossings, carried in stock in sizes to meet most requirements.

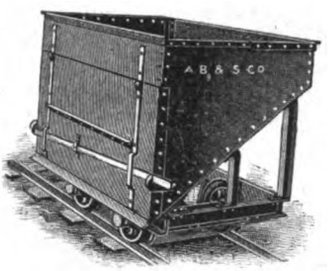
The following illustrations are typical of the lines mentioned above and upon receipt of information, giving conditions to be met, proper equipment can be furnished.

Our production devoted to special cars to more economically handle materials.

No. 259. Round Bottom All Steel Ore Car



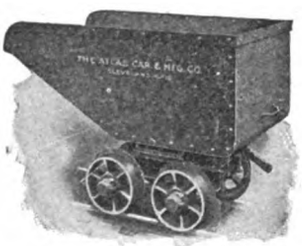
No. 243. Rotary Ore Car



No. 164. One Side Delivery Car.

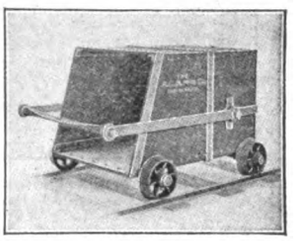
No. 272. End Dump Incline Car.

No. 217-S. Side Rocker Dump Car, Small Capacity. Plain Wheels.



No. 261. Standard Scoop Car, Rotary

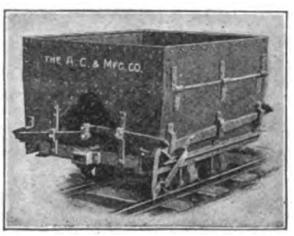
No. 150-AE. Electric Concentrate Car



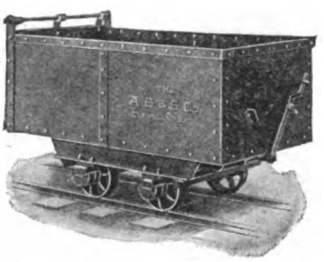
No. 801. Steel Ore Skip

No. 159. Steel Gable Bottom Car, Large Capacity, Standard Gauge

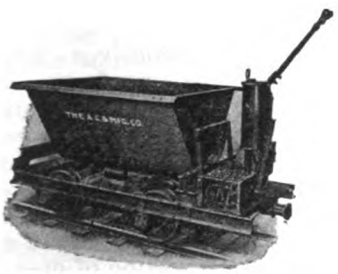
No. 258. Heavy Duty Quarry Car



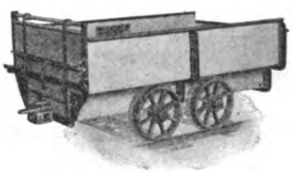
No. 161-A. Steel Gable Bottom Car



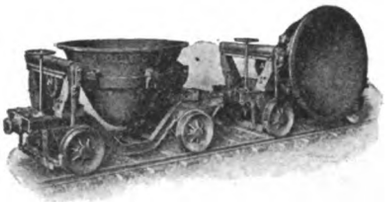
No. 270. End Dump Mine Car



No. 217-E. Side Dump Car Equipped With Motor

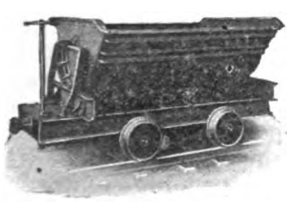


No. 288. All Steel Mine Car

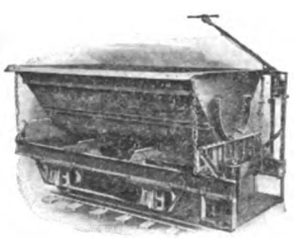


No. 194. Hot Metal or Ladle Car

No. 802. Mine Skip Automatic Dump



No. 217-H. Side Dump Car, Heavy Construction for Steam Shovel Use



No. 217-EH. Large Capacity Electric Side Dump Car

No. 600. Steel Dumping Bucket.

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THE IRONTON ENGINE COMPANY

Main Office and Factory, IRONTON, OHIO

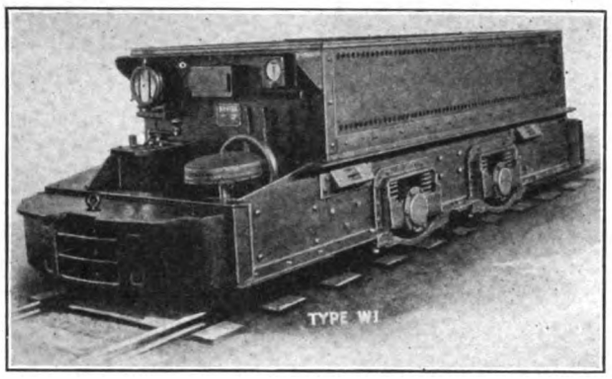
Branch Offices
PITTSBURGH PHILADELPHIA CHICAGO
DENVER SEATTLE
HUNTINGTON, W. VA. LOUISVILLE, KY.
BIRMINGHAM, ALA.

THE IRONTON STORAGE BATTERY LOCOMOTIVES

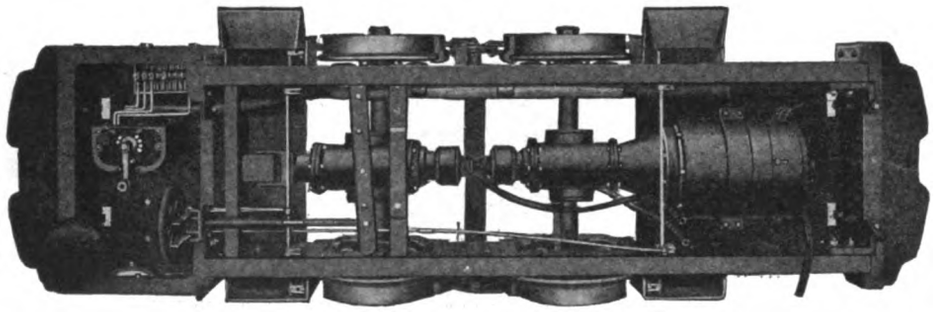
Canadian Representative
POWLEY & MOODY, Ltd., TORONTO

Storage Battery and Combination Locomotives

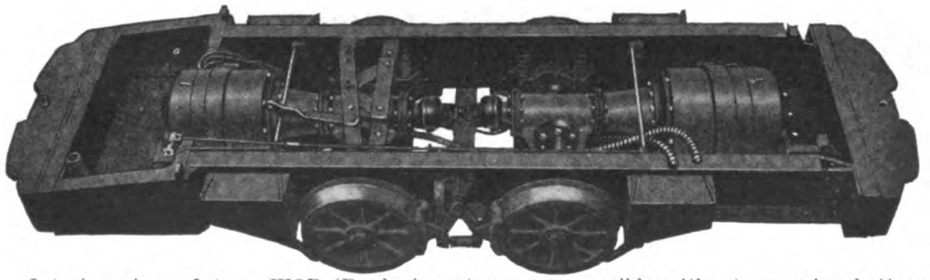
The Type WI Ironton storage battery locomotive was designed especially for metal mine service. It is built in three standard sizes, approximate weights 4, 5, 6 tons. Battery capacity varies according to requirements. Wheels are inside of frame for gauges of 18″ to 36″ and inside or outside as desired for gauges of 36″ and up.



Type WI-Single motor, worm drive to both axles. General dimensions, 6000 lb. Chassis (with 25 kwh. battery) for 24″ gauge; length, 10′-1″; width, 42″; height, 44″; wheel base 36″.



Interior view of type WI and WO locomotive. Wheels are placed inside of frame for gauges narrower than 36″. Motor is accessible without removing battery box.

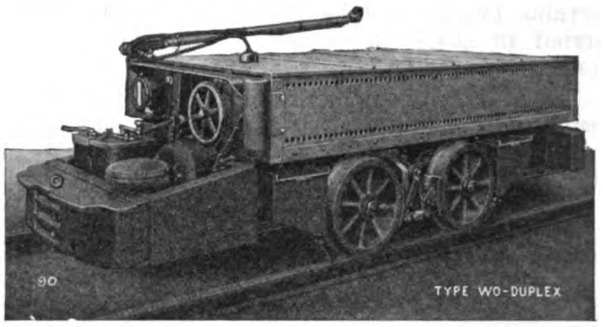


Interior view of type WOD-(Duplex) motors are accessible without removing battery compartment. Separate motors for battery and trolley operation. Both axles are direct connected to each motor.

A single motor of medium speed drives both axles, which are connected through worm shaft with universal couplings.

The outstanding features of Ironton locomotives are: rugged construction; accessibility; small number of parts in driving mechanism; economical in upkeep and operating costs; complete inclosure of all moving parts. Complete specifications furnished on request.

The Ironton Duplex (combination) locomotive is the ideal machine for situations where safety



Type WOD-(Duplex) Single motor drive to both axles from battery or trolley motor.

demands the elimination of trolley wires at loading or discharge points, but in which trolley equipment is needed because of length of haul. It operates at highest efficiency either as a battery or trolley locomotive, because (1) each motor operates at the voltage for which it was designed; (2) each motor is connected to both axles (through worm gears), producing maximum tractive effort from either source of energy; (3) it operates at a speed of 3½ miles per hour at rated drawbar pull when operated from the battery, and six miles per hour when operated from the trolley.

Ironton locomotives are guaranteed to perform a definite duty cycle, and our recommendations of size, type and battery capacity are made on the basis of work to be performed. While we prefer to have a sales engineer make a personal investigation of operating conditions, time may frequently be saved by furnishing the following information with your inquiry: A sketch indicating sections where locomotives would be used, and distances to be traveled; per cent. of grade in favor or against the loads; approximate tonnage per day required from each section; weight of car empty and loaded; approximate number of cars per trip; gauge of track; height and width of entries; radius of curves; kind of electric current available—frequency and voltage.

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Mancha Storage Battery Locomotive Co.

ST. LOUIS, MO.

Representatives in Pittsburgh, Pa.; Fairmont, W. Va.; Huntington, W. Va.; Columbus, Ohio, and Birmingham, Ala.

Agents in San Francisco, Denver, Salt Lake City, Seattle and Minneapolis.

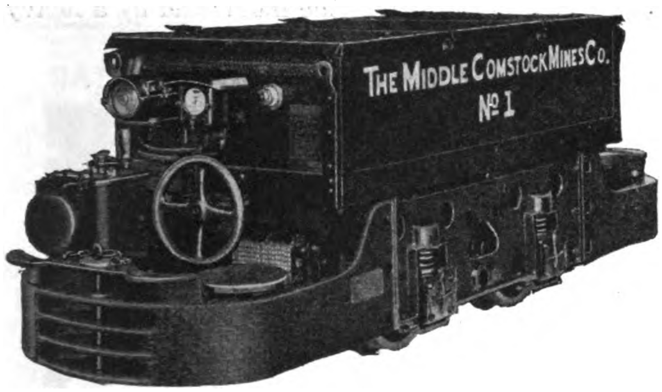
Manufacturers of

Storage Battery Locomotives

The storage battery locomotive of today has come to stay, since, due to the great strides made during the last few years in its development, the fact has been brought out most forcibly that for reliability, efficiency and increased hauling capacity the storage battery locomotive is so far superior to the old-time methods of mule haulage and hand tramming that the use of the latter methods in many instances precludes the possibility of profitable operation.

Mancha's Electric Mules are built in three general types as follows:

1. Metal mine type, especially adaptable to the narrow gauges and light service so common in this class of work.
2. The high type haulage locomotive. This type is equally well adapted for both coal and metal mining and on gauges 30" and over.
3. The low type locomotive. These locomotives can operate in seams where the clearance above the rail is as low as 30 inches and have proven a wonderful saving in low seam mines.



Metal Mine Type 1½ to 4 ton.

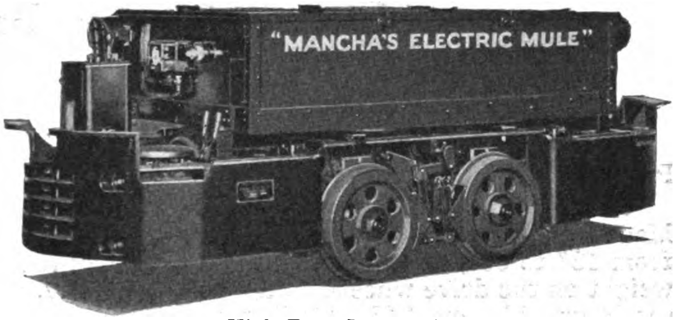
Each locomotive is a self-contained power unit since the storage battery with which each locomotive is equipped, supplies the necessary energy, requiring no external source of supply, no trolley wires nor any bonding of rails.

The battery is charged at night or between shifts from a small automatically controlled charging set located at any convenient point.

Power requirements are very low and charging equipment can be furnished for any condition.

Cost of operation therefore is extremely low and due to the simplicity of operation, a Mancha Locomotive is the safest motive power to install in a mine.

There is no danger from electric shocks from overhead wires, nor are there any poisonous fumes or exhaust gases.



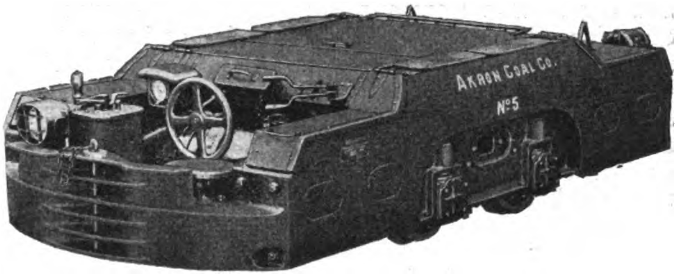
High Type Locomotive

For convenience in transporting over pack trails the smaller locomotives can be dismantled so that no single piece shall weigh over 400 lbs.

A maximum of production is assured with the Mancha Mule with all haulage worries eliminated.

Sound engineering principles are behind our design and many features are exclusive with us.

We are manufacturers of storage battery locomotives only and due to this concentration of effort on only one product we have developed a locomotive which in performance, and in durability and quality of construction knows no equal.



Low Type Locomotive

We invite your most rigid comparison and shall be glad to give you the benefit of our experience towards solving your haulage problems without obligating you in the least.

Write our nearest representative.

TABLE OF SPECIFICATIONS

	METAL MINE TYPES			HIGH TYPES				LOW TYPES	
	Standard-A	Titan-A	Titan-B	Hercules	Standard	Bear Cat	Titan	Armored Tank	Whippet
Total Weight in Tons	3¾—4½	2¾—3¼	1½—2	6—7	5—6	3—4	2½—3¼	6—7	4½—5½
Weight Chassis, Pounds	5400	3500	2400	8800	8200	5000	4000	9000	7200
Weight of Maximum Size Battery	3700	2650	1500	5900	4000	3300	2700	5200	4000
Rated K.W.H. Capacity	22 to 34	18 to 23	10 to 15	39 to 53	32 to 43	23 to 30	17 to 24	35 to 47	24 to 38
Wheel Base	32⅜"	28½"	25½"	36¾"	29¼"	29⅝"	24¾"	36¾"	29¼"
Length Over All	11'-0"	9'-0"	7'-6"	12'-1"	11'-4"	9'-8"	8'-8"	12'-9¼"	11'-7"
Length Over Frame	......	......	......	10'-6"	9'-9"	8'-4"	7'-4"	10'-9¼"	9'-7'
Height Chassis Only	20"	18½"	18½"	23½"	23½"	18½"	18½"	33"	30'
Height Over All	39¼" to 42"	37½" to 39"	37½" to 39"	43" to 46"	43" to 46"	38" to 39½"	38" to 39½"	33"	30'
Height Draw Pockets	6½" to 16"	6½" to 15"	6½" to 15"	9" to 18"	9" to 18"	7" to 16½"	7" to 16½"	8" to 19½"	6½" to 18"
Gauges Wheels, Inside	18" to 29"	14" to 23"	14" to 23"	30" to 37"	24" to 37"	22" to 35"	22" to 35"	30" to 48"	30" to 48"
Gauges Wheels, Outside	30" to 42"	24" to 42"	24" to 42"	38" to 48"	38" to 48"	36" to 42"	36" to 42"	40" to 48"	42" to 48"
Width Wheels, Inside Gauge, Plus	All Three Sizes Built in 36"—45" and 51"			22"	22"	16"	16"	22"	19"
Width Wheels, Outside Gauge, Plus	Widths Depending on Gauge.			8"	8"	5"	5"	14"	6½"
Diameter of Wheels	16"	16"	16"	19"	19"	16"	16"	19"	18"
Radius of Minimum Curve	10'-0"	9'-0"	8'-0"	12'-0"	10'-0"	9'-0"	8'-0"	12'-0"	10'-0"
Speed Miles Per Hour	3 to 6½	3 to 7½	3 to 7½"	3 to 6½	3 to 6½	3 to 6½	3 to 6½	3 to 6½	3 to 6½
Maximum Draw Bar Pull, Pounds	2250	1650	1000	3500	3000	2000	1650	3500	2750

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GEO. D. WHITCOMB COMPANY

Main Office and Works

ROCHELLE, ILLINOIS, U. S. A.

Sales Representatives in All Principal Cities

Electric Storage Battery Locomotives

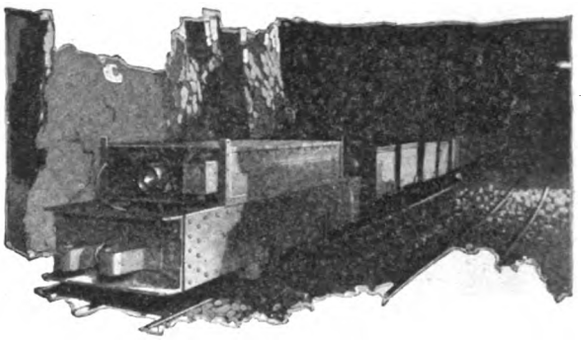
Products

Electric Storage Battery Locomotives for Mines. Made in both gear and worm drive and in gauges from 18″ to 60″, and in sizes from 2-ton to 20-ton weight on the drive wheels. Gasoline Locomotives see Pages 344 and 345. Trolley Locomotives see Pages 328 and 329.

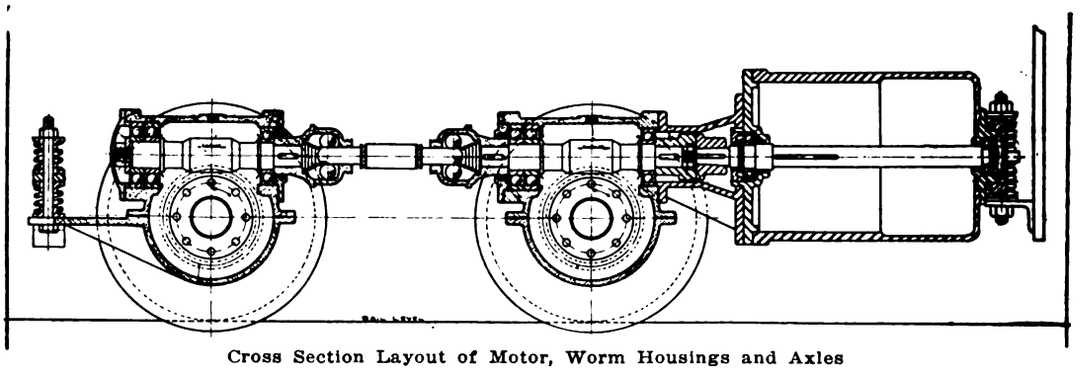
Construction

THE MOTOR—We build all of our electric motors in our own shops, assuring a unit of flexibility and dependability, guaranteed to have sufficient power to slip the wheels of the locomotive. The armature is of the Ironclad type, the core being built of laminated steel. The armature coils are made of flat ribbon wire, which are hung below the face of the armature core and are secured by being imbedded and wedged below the surface. The armature shaft, made of alloy steel, is mounted on ball bearings. The Commutator is of hard drawn or drop-forged copper with the best of mica insulation, slightly undercut to allow free brush contact. The brush holders are of heavy bronze, easily accessible and of improved design. The case and end plates are of cast dynamo steel of rigid construction and designed to allow instant attention to the commutator and brushes. The entire motor is suspended at three points, distributing the weight evenly between the frame and axle, at two points the suspension is by a duplex spring, at the third point by rigid attachment to the worm case, which in turn floats on the axle. The drive is direct to the worm gear through a tongue and groove type coupling which, when placed in a vertical position, will allow removal of the motor without disturbing the gears or gear case.

WORM GEAR AND WORM WHEEL—Realizing from the first the quality of worm gears made by the Timken Detroit Axle Company, our engineers sought their co-operation and suggestions in the design of this locomotive. Their product was accepted as standard equipment, with the result that an efficiency of from 90 to 96% is maintained. The worm, which is directly connected to the armature shaft, is carried on the motor end by a heavy duty ball bearing, the opposite end is carried by twin or duplex type Radial Thrust Ball Bearings having a thrust capacity of 200% of the radial load. These bearings take up any thrust action in either direction. The worm wheel, which is in turn driven by the worm, is located directly on the axle, providing a most positive drive. The housing encasing these parts is of two sections, made of



Locomotive in Lead Mine



Cross Section Layout of Motor, Worm Housings and Axles

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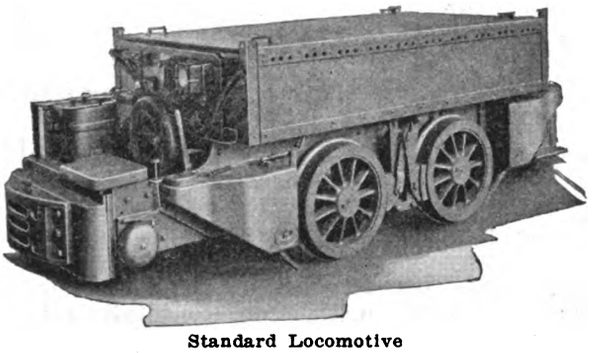
Electric Steel Castings. This case is carried on the axle on heavy duty ball bearings, which hold the worm and worm gear in the proper relation and prevent sag and undue wear. The case is constantly filled with oil, and arrangement is made for reoiling without the disturbance of any parts. The reduction, varying from 8:1 to 12:1, combined with a fairly high motor speed, ranging from 1000 to 1200 R.P.M., permits of a high degree of efficiency. A worm and wheel of like construction are also located on the rear axle. The two worms are connected by an alloy steel shaft and two universal joints, allowing free and independent action, as well as a positive and uniform drive from one motor to both axles.

AXLES—The axles are of M. C. B. specification steel and are carried in journal boxes on heavy duty ball bearings. The wheels are cast iron with chilled tread, although cast iron centers with steel tires can be furnished when so desired.

FRAMES AND BUMPERS—The frames are built up of high grade universal mill sheets and structural shapes having an average ultimate tensile strength of 60,000 pounds per square inch. The bumpers, made of heavy channel, are augmented by heavy bumper pockets.

BATTERY BOX—The Battery compartment is of single pass blue annealed sheets, and is properly lined to prevent shorting or arcing of the batteries. This compartment is easily removable, allowing full access to the chassis beneath.

CONTROLLER—The controller is of the standard drum type, fully encased and of sufficient capacity to prevent heating under full load. It is provided with a reverse switch and ample capacity blow out coils. On the larger type machines both motors are paralleled and handled by a single two-motor type controller. The case on either of these controllers is easily removed, allowing admission to the drum and contacts.

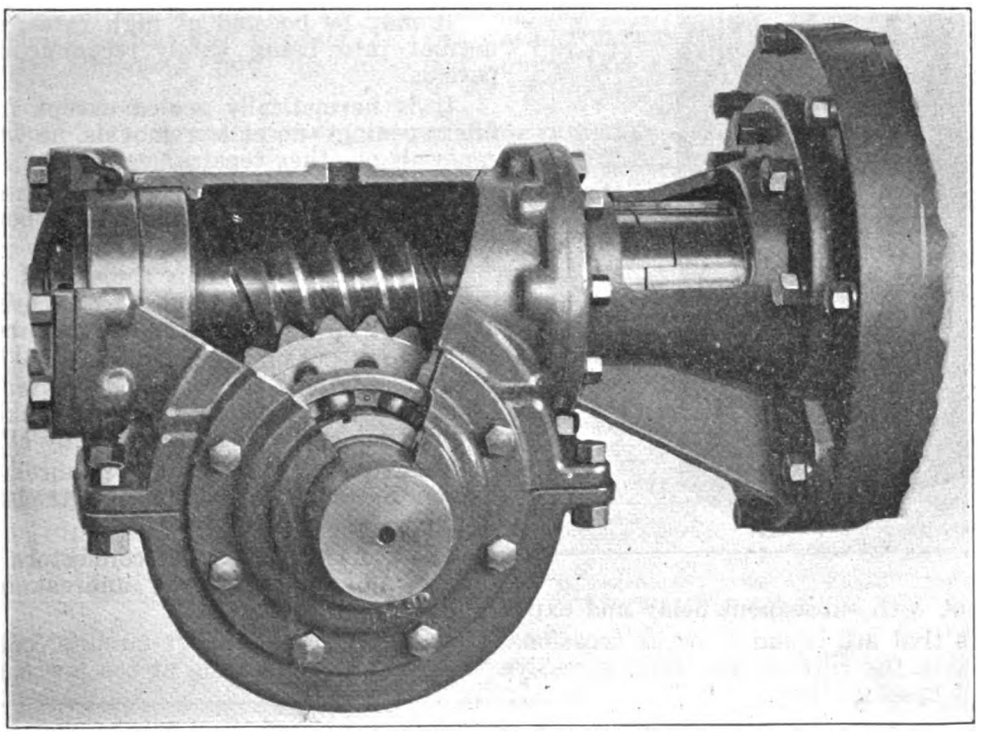


Standard Locomotive

SADER MECHANISM—Each locomotive is provided with four sand boxes operated by a lever at the driver's seat. These boxes are arranged for easy filling.

ELECTRICAL FITTINGS—All the connections and wiring are heavily insulated and protected. Two headlights of the indestructible type are furnished, one at each end of the locomotive. A charging plug and receptacle is placed in a position that will allow recharge of the batteries without removal from the locomotive, although the battery box and batteries may be lifted from the chassis by breaking the connections.

BATTERIES—Any standard make of battery desired will be furnished.



Cutaway View Showing the Motor Coupling and Worm Gear Case Arrangement

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Edison Storage Battery Company

Factory and Main Office
316 LAKESIDE AVENUE, ORANGE, N. J.
Export Division: 26 West Broadway, New York City

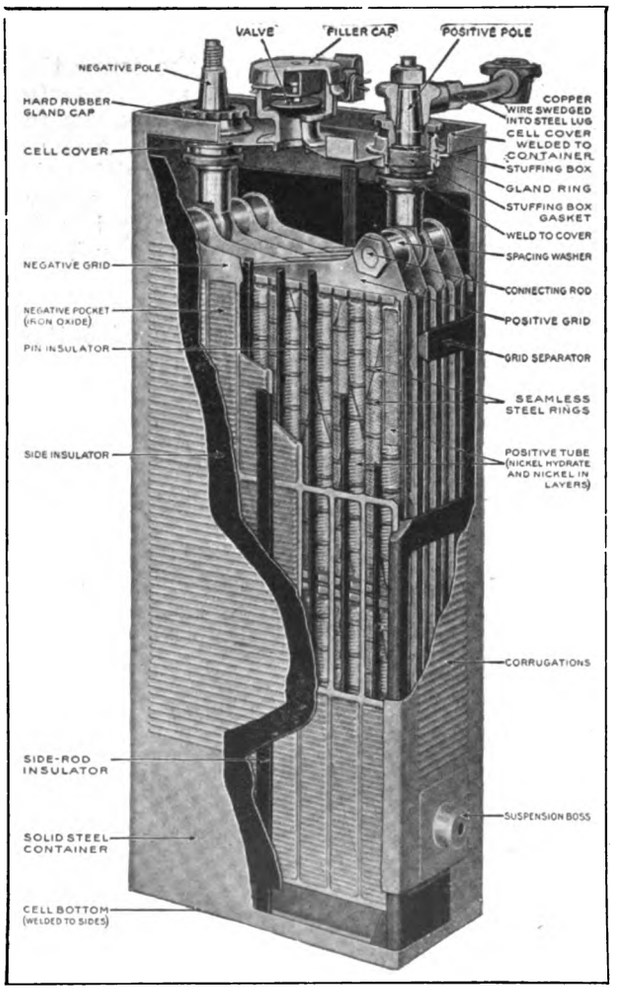
Thomas A. Edison — A PRODUCT OF THE EDISON LABORATORIES

Distributors in

NEW YORK	BOSTON	PHILADELPHIA	CHICAGO	SAN FRANCISCO
ATLANTA	CLEVELAND	PITTSBURGH	ST. LOUIS	SEATTLE
NEW ORLEANS	DETROIT	WASHINGTON	MONTREAL	LOS ANGELES

Edison Storage Batteries for Use In Storage Battery Locomotives

The Edison Storage Battery employs a principle differing radically from that of all other storage batteries having commercial importance at the present time. It is the only storage battery having iron or steel in its construction. So totally different is it from all other storage batteries that from the time the charging current enters an Edison Battery at the positive pole, until it reaches the negative side, it encounters no single metal, liquid or chemical, familiar to other batteries or any previously used methods of battery construction. Instead of lead grids, its grids are of steel. Instead of rubber or glass jars, its container is of steel. Instead of acid electrolyte, it employs an alkaline solution. Its active materials are compounds of nickel and iron instead of compounds of lead. These changes are important because by virtue of the nature of the new combination greater strength, longer life and increased durability are achieved, together with a simplicity in care and operation not hitherto possible.



A few of the exclusive advantages resulting from its distinctive characteristics, follow:

It is light in weight.

The steel container is unbreakable.

It suffers small loss of charge when idle.

No frequent hydrometer readings are necessary.

The tray assembly and cell connections are simple.

Severe vibrations and concussion have no effect upon it.

It steadily increases in capacity for the first eight or twelve months.

Temperature of electrolyte may rise to 115 degrees Fahrenheit without harm.

Sulphation and kindred "diseases" like buckling or growing of plates, are impossible.

It may be boosted at high rates, several times normal rate being safely recommended for short periods.

It is hermetically sealed except for the single filler opening—no plate removals, no wood separator renewals or other repairs needed.

It may be left standing idle, either charged or discharged, for months at a time without injury and with absolutely no attention.

It gives off no noxious fumes and can be placed in any environment without fear of corroding nearby metal or injuring persons in the neighborhood.

It can be put on charge at any time, regardless of how little or how much of the previous charge has been used, and similarly it may be taken off charge at any time and used, whether fully charged or not.

No expert battery man is required to handle an Edison Battery. Your mine electrician can secure the very best of results.

The Edison cell to cell connectors are made of copper and are practically unbreakable. No lead strap to burn out with subsequent delay and expense incident to their repair.

Accidents that are bound to occur occasionally, as, for example, short circuits, continued overcharges, charges in the reverse direction, excessive "boosting," or charging at too low a rate, have no permanent effect upon its life.

Write for a Copy of Storage Battery Locomotive Bulletin No. 608

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The Electric Storage Battery Company

General Offices and Works

PHILADELPHIA, PA.

PHILADELPHIA	ST. LOUIS	SAN FRANCISCO
CHICAGO	ROCHESTER	DENVER
ATLANTA	KANSAS CITY	WASHINGTON
DETROIT	CLEVELAND	MINNEAPOLIS
PITTSBURGH	BOSTON	CINCINNATI
NEW YORK		SEATTLE

EXIDE BATTERIES OF CANADA, Limited, TORONTO

The Exide-Ironclad Battery

Designed to Meet Every Requirement of a Heavy Duty Battery

The Exide-Ironclad Battery is one of many types produced by The Electric Storage Battery Company—the oldest and largest manufacturers in the world of storage batteries for every purpose—and is especially built to meet the particular requirements of mine locomotive service.

It is designed with a full realization of the fact that locomotives can be kept going at the top of their speed and power, only by batteries which possess the four following essential operating characteristics:

1. Reserve Power.
2. Sustained Energy.
3. Ruggedness.
4. Low cost per Ton.

Under the first heading, it can be said of the Exide-Ironclad Battery that it delivers increasing power up to twenty times the normal rate of discharge.

As to its sustained energy—the voltage remains high throughout the entire discharge, which means power and speed all day long.

The ruggedness of the Exide-Ironclad Battery is almost proverbial. Assembled in practically unbreakable rubber compound jars, the jolts and vibrations incidental to the coupling of cars and fast travel over uneven road beds have little effect on it.

And as to low cost per ton, the first cost of the Exide-Ironclad, plus cost of upkeep divided by the number of tons hauled will give a surprisingly low cost per ton.

The long life of the Exide-Ironclad Battery is due in no small degree to the unique construction of its positive plates and the method of assembling them in the jars so that liability of internal short circuiting is reduced to a minimum.

Data is available of mine locomotives running four years with no repairs to their Exide-Ironclad Batteries — convincing evidence that they have long life, give dependable day in day out service, are economical, and require but minor care and attention.

Cut - away cell showing the sturdy positive plate and how it is supported by a different set of ribs than those which hold the negative plates. This construction reduces to a minimum the liability of internal short circuiting.

USEFUL DATA ON THE EXIDE-IRONCLAD BATTERY

Number of plates	7	9	11	13	15	17	19	21	23	25	27	29	31	33
Ampere hours service capacity (over 6 hours)	102	136	170	204	238	272	306	340	374	408	442	476	510	544
K. W. hrs. service capacity (over 6 hrs.) at 1.97 volts per cell	.201	.268	.335	.402	.469	.536	.603	.670	.737	.804	.871	.938	1.005	1.072
K. W. hrs. service capacity (over 6 hrs.) for 48 cells at 1.97 volts per cell	9.65	12.86	16.08	19.29	22.51	25.72	28.94	32.15	35.37	38.58	41.80	45.01	48.23	51.44
Discharge in amperes for 4½ hrs. (average voltage 1.97 per cell)	21	28	35	42	49	56	63	70	77	84	91	98	105	112
Outside dimensions of cells, not including trays, in inches — Length	2 7/8	3 5/16	4 1/16	5 1/16	5 7/8	6 5/8	7 3/8	8 1/8	8 7/8	9 5/8	10 3/8	11 1/8	11 7/8	12 5/8
Width	6 1/16	6 1/16	6 1/16	6 1/16	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4	6 1/4
Height 2¾ in. ribs.	15	15	15	15	15 1/16	15 1/16	15 1/16	15 1/16	15 1/16	15 1/16	15 1/16	15 1/16	15 1/16	15 1/16
Weight of electrolyte	4¼	5½	6¾	8	9¼	10½	11¾	13	14¼	15½	16¾	18	19¼	20½
Weight of complete cell	23¾	30	36½	42¾	49½	57¼	63½	70	76¼	82¾	89	95¼	101¾	108
Approximate weight per cell, including tray	27	35	42	49	57	66	73	81	88	95	102	110	117	124

	Volts per Cell			Volts 48 Cells		
	Initial	Average	Final	Initial	Average	Final
At 4½-hour rate	2.06	1.97	1.755	98.88	94.56	84.24
At 3 times 4½-hour rate	1.97	1.88	1.665	94.56	90.24	79.92
At 5 times 4½-hour rate	1.88	1.79	1.575	90.24	85.92	75.60

Height given is from bottom of jar to top of intercell connector, except where vertical diagonal connector is used when height should be increased ⅞ inch.

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GEO. D. WHITCOMB COMPANY

Main Office and Works

ROCHELLE, ILLINOIS, U. S. A.

Sales Representatives in All Principal Cities

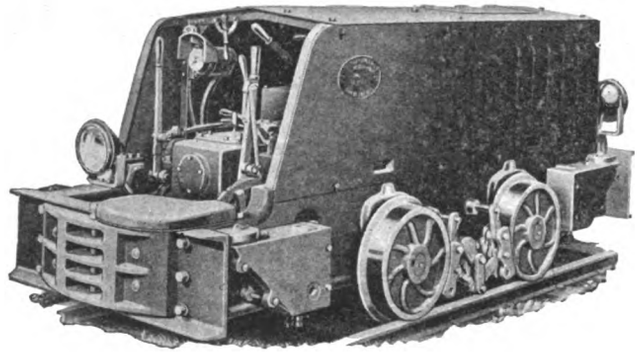
Gasoline Locomotives

Products

Gasoline Locomotives for Mines. Made in sizes from 3 tons to 8 tons and in gauges from 18″ to 60″. Trolley Locomotives see Pages 328 and 329. Storage Battery Locomotives see Pages 340 and 341.

The Company

The Geo. D. Whitcomb Company was the first in the United States to build and install a gasoline locomotive. That was eighteen years ago. Today there are thousands of Whitcomb Locomotives in successful operation.



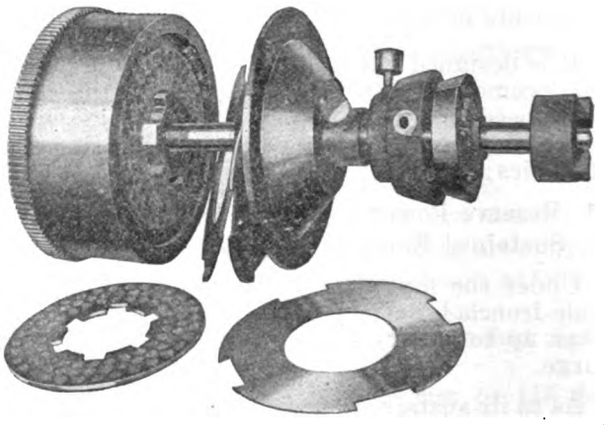
Mining Type Gasoline Locomotive

Construction

ENGINE—The power plants are either Waukesha or Wisconsin, depending upon the size of the locomotive. These motors have been adopted after many tests with many makes and are the best of tractor type engines built today. The crank shaft is of chrome nickel steel and has extremely large bearing surface. All parts of the engine are oiled by a force feed system, operating under a thirty-pound pressure. The cylinders are of the removable head design, bored and ground to size. The cooling system is handled by a centrifugal pump of rugged design and is so arranged that the entire system may be drained from one point.

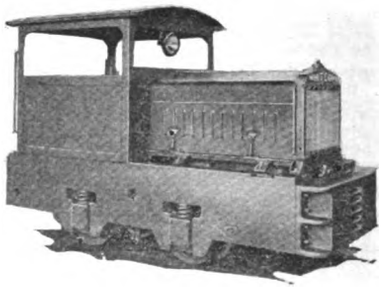
The valves are of special alloy, split washer, taper type, with flat case hardened end. Every part of the motor is of the best design and material.

INGITION—Standard equipment includes an Aero type Dixie Magneto, equipped with an adjustable coupling and impulse starter coupling.



The Whitcomb Multiple Plate Clutch

CLUTCH—The clutch is made entirely in our own factory, is of excessive capacity and of the very latest design. The construction is alternate discs of saw steel and aluminum, the latter filled with cork inserts. The saw steel plates are driven by lugs on the flywheel which houses the entire mechanism. The aluminum discs are carried on and drive a splined spider, which is part of the clutch shaft.



Cab Type Gasoline Locomotive

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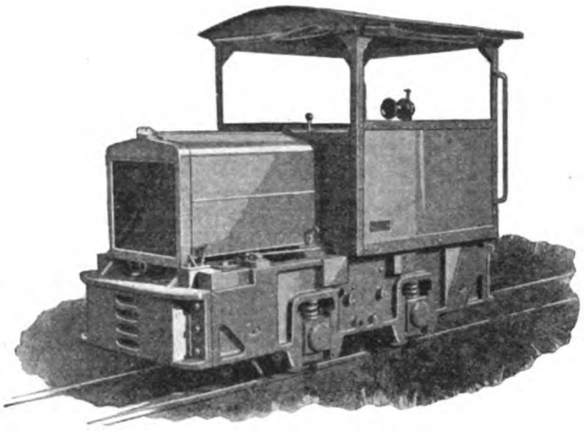
The clutch surface is of such size that a pressure of only five pounds per square inch of cork is necessary to transmit the full power of the engine. The pressure between discs is maintained by a heavy coil spring, which acts directly against a thrust plate. No toggles or levers are used and this spring automatically takes up all wear and makes adjustment unnecessary. The clutch is supplied with an improved spinning brake, which works automatically as soon as the clutch is fully released. The fact that the clutch runs in oil ensures its durability and an easy starting torque, as, when the clutch is first engaged, a film of oil separates the corks and the steel plates, allowing a slight slippage for the first two or three revolutions.



Four-Ton Cab Type Locomotive

TRANSMISSION—The transmission is of the selective gear type, permitting three speeds in each direction. The variation in speed is controlled by a speed change lever operating three pinions located on the clutch-driven shaft which drive directly onto corresponding gears on the transmission shaft. At the end of this shaft is a bevel pinion which engages two bevel gears running idle on the jack shaft. Splined to the jack shaft is a drop-forged chrome vanadium jaw clutch controlled by a forward and reverse lever. This clutch engages directly with either bevel gear. As these bevel gears run in opposite directions a full driving power is obtained in either direction. This clutch has also a neutral position for idling. The speed change lever is likewise arranged with a neutral position. Cut steel sprockets are located at each end of the jack shaft. These sprockets drive directly onto the front axle with two 2″ pitch roller chains of standard make. All of the gears, pinions and sprockets are chrome vanadium drop forgings carefully machined and heat treated. The shafts are nickel steel and are carried entirely on ball bearings. The case is of heavy cast construction built in three parts, allowing free access, and is so constructed that all parts run in oil. All like parts for this transmission are interchangeable.

RADIATOR—The radiator is of the artillery type developed and adopted by the Government during the world war. The shell is of cast iron, to which are bolted the cooling cores or sections. This type of radiator permits of quick repair either by replacing with new sections or applying blind gaskets in place of a damaged section, the only tool required being a monkey wrench. The radiation is sufficient for the most adverse working conditions.

AXLES AND WHEELS—The axles are made of forged steel carefully machined, and are carried on heavy-duty ball bearings. These bearings are located in cast axle or journal boxes located in the frames, and are so arranged that chain slack can be taken up by means of shims. The sprockets are cast steel of the split design, to allow removal without disturbing the axles. The drive is so arranged that all four wheels are drive wheels. The wheels are rolled steel. Cast centers with steel tires can be furnished at additional cost.

FRAMES AND BUMPERS—The main frame or chassis is of heavy cast iron, thoroughly braced and ribbed. The bumpers are bolted to each frame and are so arranged with pockets that various draw-bar heights are obtained.

SUMMARY—Mining men who are looking for a solution of their haulage problem can readily appreciate the advantages of this rugged locomotive. The accessibility of parts, the easiness of adjustment, the positiveness of the drive, create an appeal which is fully justified. The low center of gravity gives it a stability hard to realize. It is in its entirety designed to work and built to overwork.

SPECIFICATIONS

Locomotive Size	Weight	Draw Bar Pull, Low Gear, 3 to 5 Miles on Level Track	Height, Mining Type	Height, Cab Type	Length	Wheel Base
3-ton	6000 lbs.	1200 lbs.	49″	81″	9′	32″
4-ton	8000 lbs.	1600 lbs.	49″	81″	9′	32″
6-ton	12000 lbs.	3000 lbs.	65″	88″	10′–7″	46″
8-ton	16000 lbs.	4000 lbs.	67″	88″	12′	46″

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THE BALDWIN LOCOMOTIVE WORKS

PHILADELPHIA, PA.

OFFICES

New York, N. Y.—120 Broadway.
Chicago, Ill.—627 Railway Exchange.
St. Louis, Mo.—1210 Boatmen's Bank Building.
Richmond, Va.—712-13 Mutual Building.
Boston, Mass.—185 Devonshire Street.
Pittsburgh, Pa.—375 Union Arcade Building.
Houston, Texas—1501 Carter Building.
St. Paul, Minn.—908 Merchants Nat'l Bank Bldg.
Portland, Ore.—313 Northwestern Bank Building.
San Francisco, Cal.—310 Sansome Street.

LOCOMOTIVES

Locomotives

The Baldwin Locomotive Works build all types of steam, internal combustion and electric locomotives for mining, industrial and contractors' service. The use of steam locomotives in underground work is necessarily restricted; but for surface haulage about mines, and for open pit mining operations, they are highly satisfactory. With ninety years' experience in locomotive building, we offer a product which is unexcelled in design and construction and specially fitted for the work to be done.

We call particular attention to our facilities for furnishing duplicate and spare parts for locomotive maintenance. Work of this kind is always given preference to insure prompt shipment. We recommend that a stock of those parts most subject to wear and replacement be kept on hand, so that repairs can be made in the shortest possible time.

Fig. 1

The illustrations show several types of locomotives suitable for mining service. Figure 1 represents a design used for light underground and surface haulage where clearances are closely restricted. This locomotive, of 36½ inches gauge, was designed with a width limit of 5′0″ and a height limit of 5′1″. Its total weight is 17,000 pounds. Modifications can be made in this general design to suit special operating conditions.

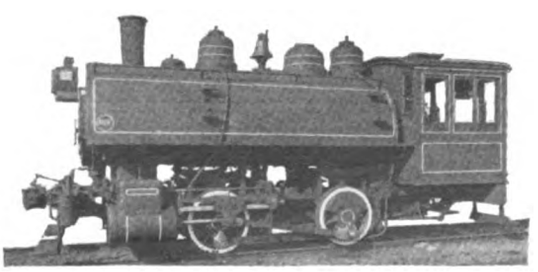

Fig. 2

Figure 2 shows a design of four-coupled tank locomotive which is suitable for general surface haulage and switching. This is a standard gauge locomotive weighing 77,500 pounds. Tank locomotives have many advantages for short-haul work, and where more powerful units are required, they can be built with three or four pairs of driving-wheels.

Fig. 3

Figure 3 shows a type of six-coupled locomotive with separate tender, suitable for general switching service and extensively used in open pit mining operations. The locomotive weighs 160,000 pounds, and the loaded tender 90,000 pounds additional. This type is built in various sizes to meet different operating conditions.

Fig. 4

Figure 4 shows a locomotive of the "Consolidation" type, suitable for comparatively long runs on mining and industrial railways. The two-wheeled leading truck provides an excellent guide when operating in road service, and approximately 90 per cent of the total locomotive weight is carried on the driving-wheels, giving ample adhesion for heavy hauling. The locomotive illustrated weighs 158,000 pounds, with 140,700 pounds on driving-wheels; and the loaded tender weighs 120,000 pounds additional. This type can be built in larger sizes, where tracks and bridges are sufficiently heavy to carry the increased weight.

Full information regarding Baldwin Locomotives for mining, industrial or contractors' service will be furnished on request.

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DAVENPORT LOCOMOTIVE WORKS

DAVENPORT, IOWA

Designers and Builders of

Rod and Gear-Drive Steam Locomotives

Gear-Drive Steam Locomotives

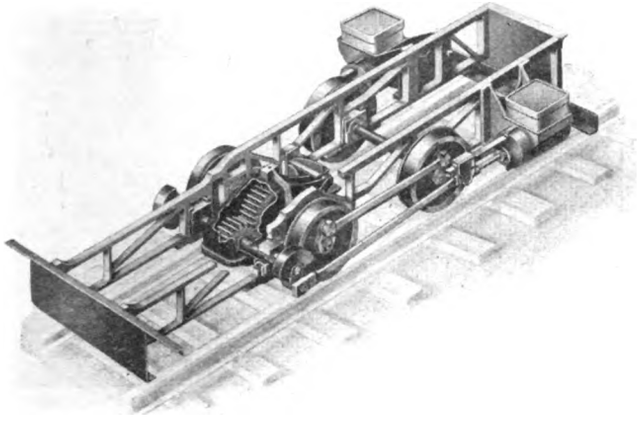
Made in two-gear and four-gear drives.

Power is applied through main rods to a crank shaft carrying a pinion which drives a large gear on the rear driving wheel axle.

A one-piece steel housing carries the bronze bearing for the crank shaft and forms the journal boxes for the rear driving wheel axle.

Gears are held in **positive alignment and mesh** by a loose ball-and-socket bearing at the apex of the housing. Power is transmitted to forward drivers through ordinary side rods, the locomotive thus being driven from all wheels and utilizing for traction all its weight.

All gears are **steel spur gears** with **extra heavy cut teeth.**



Two-Gear Drive

Locomotives are equipped with under slung, side or saddle tanks as desired.

The two-gear design is preferable where large clearance under the gear case is not necessary, although the **perfect gear lubrication** makes the friction on the four-gear drive very small.

The locomotive can be equipped with a **two-speed gear shift, operated from the cab,** which enables the engineer to increase the speed on light grades or to increase the tractive effort on heavy grades.

The four-gear design can be further adapted to track and grade conditions by a change in the gear ratio, which can be very easily made, by substitution of gears of different diameter for the pinion on the crank shaft and the gear on the intermediate shaft into which the pinion meshes.

Special Features

The design eliminates all objectionable features of other designs of geared locomotives, while retaining the tractive effort gained by gearing.

It has no bevel gears. Gears run in an oil-tight dust-proof case. If kept well lubricated, gears will not need replacement during the life of the locomotive.

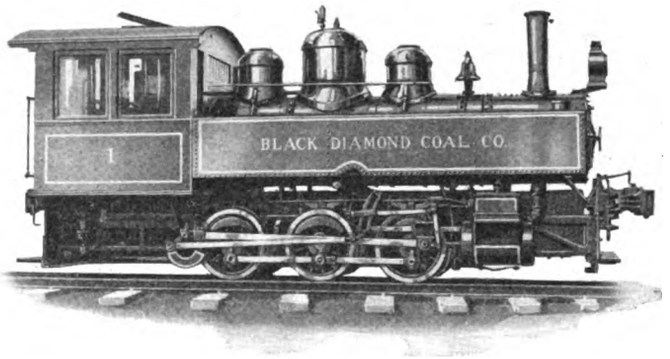
Gears are noiseless.

Cost of maintenance is no greater than that of the usual type of direct-drive locomotive. Every gear-drive locomotive built by us is still operating with the original gears.

It has great tractive power with little sacrifice of speed.

The even torque greatly increases rail adhesion, enabling the locomotive to pull loads one-third greater than direct-drive locomotives of the same weight. Great tractive power, combined with light weight, makes it especially adapted for use on **heavy grades, light rails and sharp curves.**

All of our locomotives can be equipped to burn bituminous, anthracite or lignite coal, wood or fuel oil.



Gear-Drive Steam Locomotive

Uses

Will haul cars up heavy grades to steam shovel and spot them without jerking or bumping. Will haul loaded cars to dump, as it has greater speed than can be made over usual construction track.

For hauling cars over tracks where **weight of locomotive is limited** by light rail used, light bridges, soft roadbed or other track conditions.

Our Gear-Drive Locomotives are built with the same **careful workmanship and high grade material** that characterizes the construction of all our locomotives. They are durable and reliable.

As we are buliders of both direct-drive and gear-drive locomotives, we are in a position to give impartial advice as to the type or size required, when advised as to the conditions under which the locomotive is to be used.

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H. K. PORTER COMPANY

Union Bank Building, PITTSBURGH, PA.

LOCOMOTIVE BUILDERS

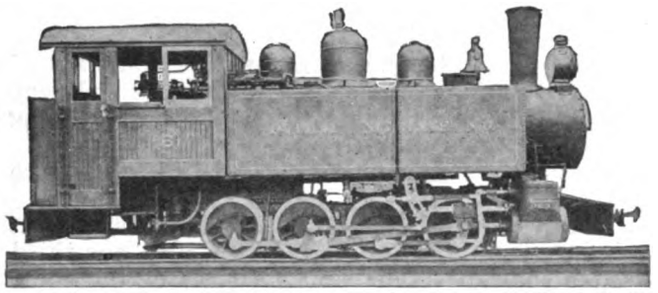
Product

Locomotives for all classes of service, metal mine, industrial, switching, contractors, coke oven and mine haulage, etc.

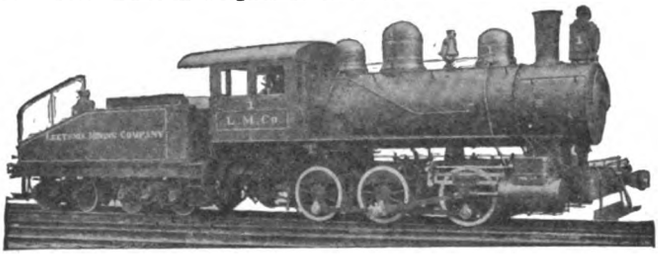
General Information

We issue to the trade complete catalogues on our Steam and Fireless Locomotives. Either or both of these books will be sent to responsible executives on application.

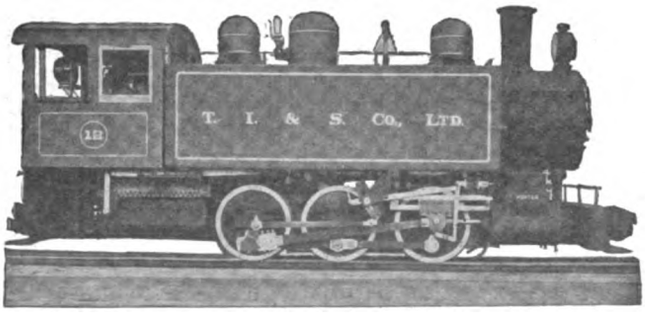
Porter Locomotives are in use in practically every country and are built and designed to meet local conditions and customs wherever required.



The above illustration shows a locomotive built for the Dupont Nitrate Company. This machine has 13x16 cylinders, Class D-SS 30" gauge of track, 64,000 lbs. weight in running order, 33" driving wheels, 180 lbs. boiler pressure, 12,535 lbs. tractive force, equipped for burning oil fuel and with Walschaert valve gear. This design is very desirable for service where great power is required on light rail and soft road bed. Built in weights 16 to 90 tons.



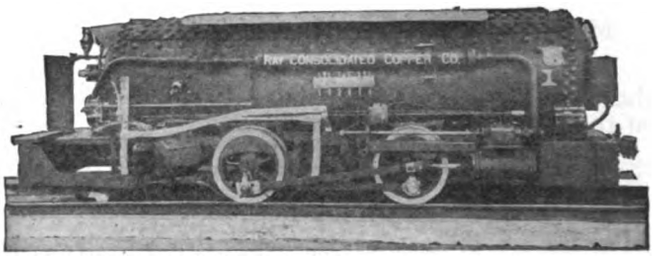
The locomotive shown by the above illustration, which was built for the Leetonia Mining Company for use on the iron range in Minnesota, has 17x24 cylinders, Class C-T, weighs 96,000 lbs. in working order, has 44" driving wheels, 170 lbs. boiler pressure, 22,775 lbs. tractive force. The tender weighs 60,000 lbs. in running order and carries 3,000 gallons of water and 8,000 lbs. of coal. This is the familiar "six-wheel-switcher" type, for general yard work and runs on which much power and ample water and fuel capacity is required in a locomotive that will pass sharp curves. Built in weights from 7½ to 85 tons.



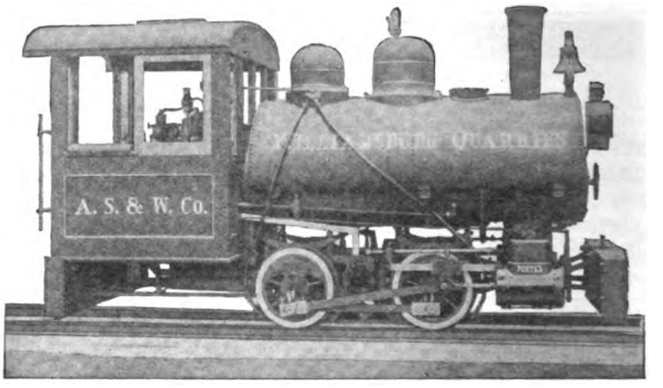
The above locomotive was built for the Tata Iron & Steel Company, Ltd., for export to India. It has 19x24 cylinders and is only 36" gauge. It weighs 145,000 lbs. in working order, 46" driving wheels, 190 lbs. boiler pressure, 30,415 lbs. tractive force. This is a most excellent locomotive for general switching purposes where the run is not of sufficient length to justify a separate tender. Built for all gauges in sizes from 7 to 85 tons in weight.

The interchangeable part system is used, which makes repairs and replacements easy and avoids delays and loss of time in the shop.

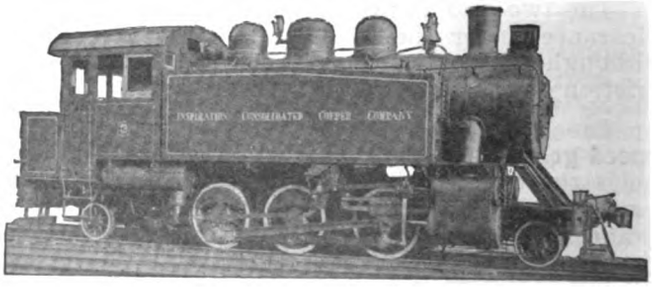
Detailed drawings, specifications, prints, etc., will be gladly furnished to all prospective buyers.



The above compound compressed air locomotive was built for the Ray Consolidated Copper Company, of Ray, Arizona. The high pressure cylinder is 6" dia. x 12" stroke and the low 12"x12", 30" gauge, 16,500 lbs. weight in working order, 24" drivers, 3,600 lbs. tractive force, and the main air reservoir carries an initial charging pressure of 850 lbs. Porter compressed air locomotives are built in all sizes, types and gauges within the limitations of adaptability for this system of haulage, and for all classes of service where, on account of safety from fires, cleanliness, ventilation, or other reasons, steam locomotives are not desired. In gaseous mines where even an electric spark is liable to cause an explosion, compressed air locomotives are absolutely safe.



The above Class B-S locomotive, which was built for the Williamsburg Quarries of the American Steel & Wire Company, weighs 20,000 lbs. in working order, carries 170 lbs. boiler pressure and develops 4,265 lbs. tractive force. This is the famous Porter dinkey type, which has been known to the industrial haulage field for more than fifty years. This type is built for all gauges of track with cylinders 5x8 weighing 4½ tons, to 18x24 cylinders weighing 60 tons or more.



The locomotive shown above was built for the Inspiration Consolidated Copper Company, of Miami, Arizona. It has 21x26 cylinders, Class 2-C-2-SS, 203,000 lbs. total weight in working order, 163,500 lbs. on driving wheels which are 50" diameter, 180 lbs. boiler pressure, 35,085 lbs. tractive force. The machine is equipped for burning oil fuel, has Schmidt type of superheater and Walschaert valve gear. This type of locomotive is especially adapted for light rail and uneven track where the haul is not long enough to require a separate tender. Built in any size from 17 to 85 tons weight.

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PENNSYLVANIA CASTING & MACHINE WORKS

PITTSBURGH, PA.

Manufacturers

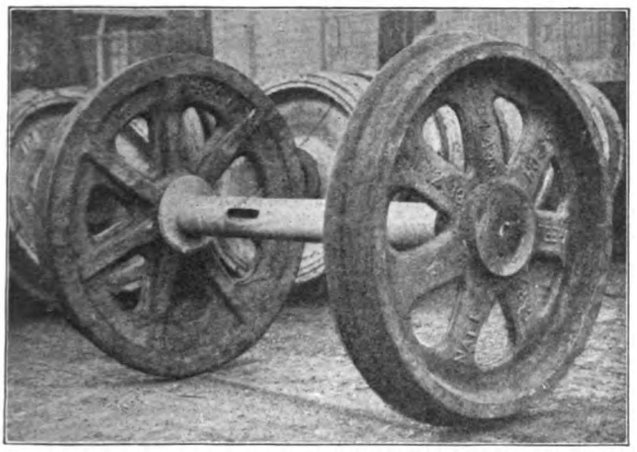
Wheels of Every Description

Products

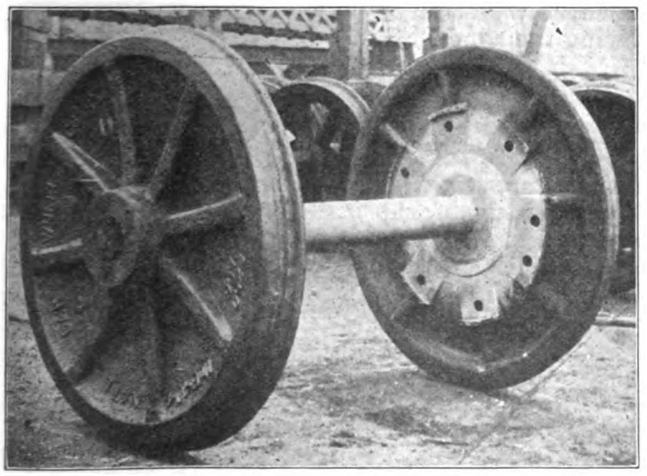
Wheels of every description for mining locomotives, dump cars and standard M. C. B. freight cars.

Our Facilities

We carry in stock at all times wheels and axles for all types and makes of mining locomotives, thus insuring you quick delivery. We also specialize in mounting new wheels on either old or new axles.



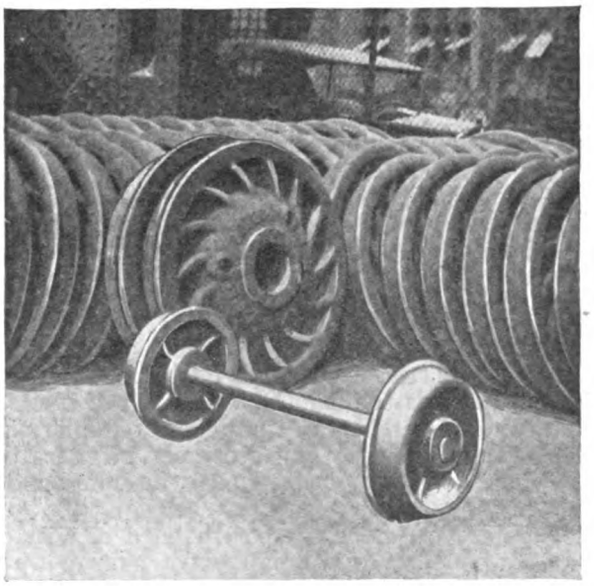
Baldwin, Westinghouse, Jeffrey, Morgan-Gardner Locomotive Wheels.



Goodman Locomotive Wheels.

Steel Tired Wheels

We supply steel tired wheels complete, or can furnish steel tires properly machined for your refitting to old centers.



Write Us for Particulars.

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INDIANA FOUNDRY COMPANY, Inc.

154 Clymer Avenue, INDIANA, PA

"Sutton" Sand Drying Stoves

Products

Sand Drying Stoves, Heavy Heating Stoves, Winches, Windlasses, Tuyere Irons, Swage Blocks, Stable Traps, Cast Iron Frogs and Turnouts, Grate Bars, Sheave Wheels, Coke Oven Dampers. Special Castings for Mines made to Order.

The Complete Sand Dryer

"Sutton" Sand Drying Stoves

"Sutton" Sand Drying Stoves are used by Mines, Collieries, Steam and Electric Railroads, Contractors, Founderies and Industrial Plants. More than one thousand of these stoves are in use in the collieries of Pennsylvania alone.

Simple in operation, massive in design, made of the best quality of gray iron; built for hard, continuous use, with each casting designed for the particular service it is to render, so that even under the most severe conditions the stove will give the longest possible life.

Skirtings are made of 16 ga. sheet steel, strongly riveted, reinforced around the top with a heavy steel band.

Operation

After having a good, hot fire started in the stove, shovel the wet sand into the sheet steel skirting, and as the sand dries, it will of itself run out through the holes in the perforated ring at the base of the skirting. This stove can be operated to its fullest efficiency by anyone who can handle a shovel.

This stove can be fired with hard or soft coal, coke or wood. For a small extra charge we can equip it to burn gas.

Sizes and Dimensions

	No. 1	No. 2	No. 3
Weight	1235 lbs.	675 lbs.	550 lbs.
Drying capacity, under normal conditions, in 10 hours	10 tons	5 tons	3½ tons
Extreme height of Sand Dryers..inches	58	49½	48¾
Height from base to top..... "	48	40	38¼
Height of legs..... "	10	10	10
Size of Firedoor..... "	10 x 12	10 x 12	11 x 11
Inside diameter ..... "	23	17	15
Grate diameter ..... "	22	15	12½
Skirting at top, diameter..... "	52	40	39
Distance from inside fire door to back of stove..... "	33	27	23¼
Thickness of castings..... "	1¼	⅞	¾
Skirting capacity, cubic feet of sand..	18½	8½	7½

External Gratings for Sutton Sand Dryers

This cut shows the upright cast iron gratings with which we surround the body of our sand drying stoves, to prevent the wet sand from coming into contact with the main stove castings.

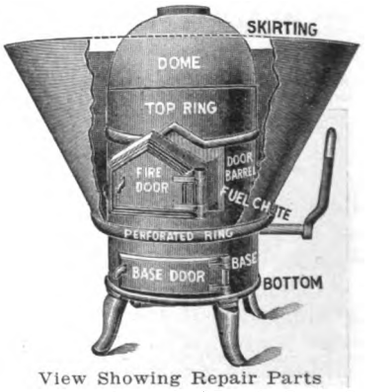
External Grating

There is an open space of about 1½" between the main stove castings and the gratings, which allows the escape of steam and gases. As the sand dries, it runs through the grating into the air space, and down through the holes in the perforated ring near the base of the stove.

By use of these gratings, more sand can be dried in a given time, and the life of the main stove castings is greatly lengthened, owing to the fact that the wet sand does not come into direct contact with them.

These gratings also form a perfect vent or flue, which permits the ready escape of the gases and steam which naturally arise during the process of drying the sand.

External Gratings are not sent unless specially ordered, and an extra charge is made for same.



View Showing Repair Parts

Repair Parts

This illustration is for ordering repairs. Order by name, and be sure to state whether your stove is No. 1, 2 or 3.

Guarantee

We guarantee the Sutton Sand Dryer to give satisfaction under all circumstances, when used for the purpose for which it is intended.

"Sutton" Sand Drying Stovs are sold by all leading jobbers.

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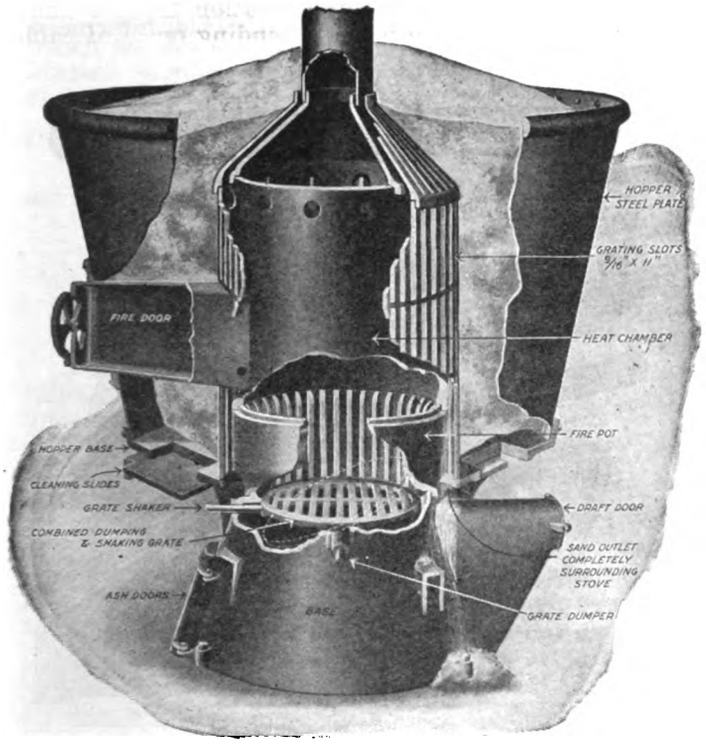
HARRY VISSERING & COMPANY

1616 LYTTON BLDG. CHICAGO

Manufacturers of

THE "VILOCO" AUTOMATIC SAND DRYER

The "Viloco" Dryer is **positively automatic.** Note the cast iron grating between body of sand and the stove, through which grating the **sand runs**



freely as fast as it dries. This arrangement prevents wet sand coming in contact with stove and allows the vapor to escape through holes at the top of the heat chamber into stack.

As sand does not come in contact with stove, all possible burning out of stove is removed. Ample cleaning slides are provided around the entire hopper base to facilitate ready removal of any material that will not pass through the cast iron grating.

The grate is a combined shaking and dumping arrangement, and can be replaced through the large ash doors, thereby making it unnecessary to dismantle the dryer in order to renew the grate.

A man having other duties can easily attend to this apparatus. Saves initial cost first year in labor.

We have reduced repair expenses to a minimum. Any number in service two years without repairs.

We will name scores of electric railways, railroads and coal mines in every section of North America, each and every one an enthusiastic satisfied customer.

Sand dryers, as usually constructed, consist of a stove surrounded by hopper of wire netting. The sand coming in contact with the stove dries first and has no means of escape until all of the sand within the hopper is sufficiently dry to start running through the wire netting forming the hopper. In the meantime, sand lying in contact with the stove becomes sufficiently hot to be thoroughly burned and materially assists in burning out the stove itself. Sand which has been burned loses its value and usefulness.

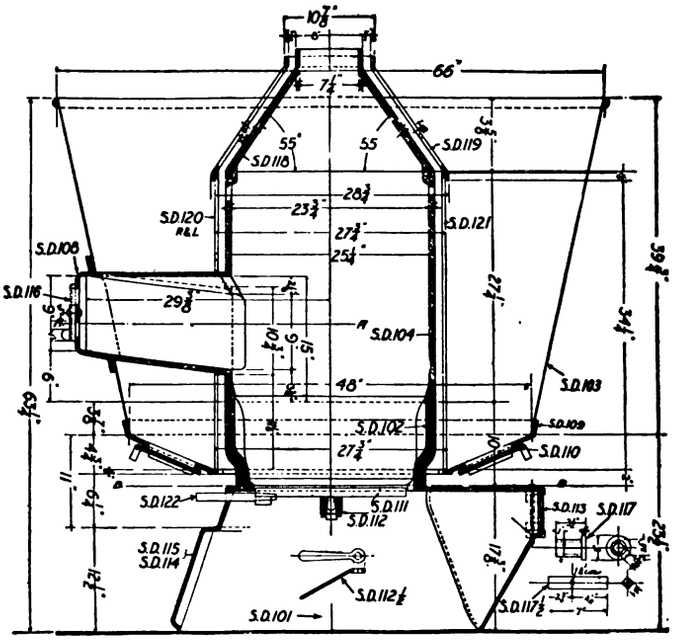
Our "Viloco" Dryer works on the principle that as soon as the sand is dry, it is free to escape. It does not burn the sand.

Why Preference is Given the "Viloco" Dryer

It is automatic in action.
It is correctly designed and built.
Stove cannot burn or break.
Cleaning slides save labor.
Durable, practical and economical.

Names of Parts

S. D. 101.	Base	S. D. 114.	Ash Door
S. D. 102.	Fire Pot	S. D. 115.	Ash Door
S. D. 103.	Hopper	S. D. 116.	Fire Door Damper
S. D. 104.	Heat Chamber	S. D. 117.	Grate Support Bushing
S. D. 108.	Fire Door	S. D. 117½.	Grate Support Pin
S. D. 109.	Hopper Base	S. D. 118.	Heat Chamber Top
S. D. 110.	Cleaning Slides	S. D. 119.	Top Grating
S. D. 111.	Grate	S. D. 120.	Grating L.H.
S. D. 112.	Grate Support	S. D. 120.	Grating R.H.
S. D. 112½.	Wrench	S. D. 121.	Grating
S. D. 113.	Draft Door	S. D. 122.	Grate Shaker Bar



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THE AMERICAN MINE DOOR CO.

CANTON, OHIO, U. S. A.

Manufacturers of

Automatic Mine Doors and Switch Throwers

Products

Cable Splicers, Trolley Splicers, Trolley Frogs, Bond Terminals, Section Insulators, Rail Benders, Spike Bars, etc.

Canton Automatic Switch Thrower

Can be used inside or outside the mine.

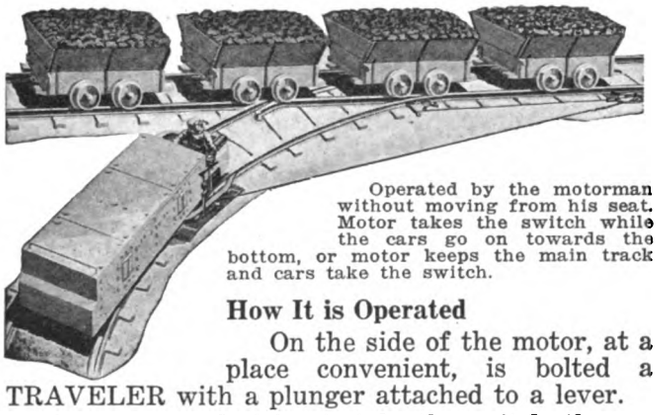
Does everything a switchman can do.

Prevents loss of time, as it is not necessary to cut down the speed when passing through the switch.

Saves loss of power, wear on motors, track and other equipment by eliminating the stop to throw switch by hand.

Safeguards life by removing the human element.

Can be operated as a hand switch at the same time.



Operated by the motorman without moving from his seat. Motor takes the switch while the cars go on towards the bottom, or motor keeps the main track and cars take the switch.

How It is Operated

On the side of the motor, at a place convenient, is bolted a TRAVELER with a plunger attached to a lever.

A motorman desiring to take the switch, throws his lever on the traveler in the operative position. This actuates the Switch Thrower, which opens the switch. He passes into the switch without decreasing his speed.

When he has passed the Switch Thrower he releases the lever and the switch will remain open, permitting him to run in and out of the switch without any further attention. Wishing to close the switch when the motorman goes out, after passing the Switch Thrower, he throws his lever, which causes the "universal tripper" to close the switch.

No complications can arise which have not been provided for.

The Canton Cable Splice

This device makes possible the saving of many feet of good cable which would otherwise be thrown in the scrap. Not only does it save cable, but the splice when made is more durable, neater in appearance and requires less time to make and less cable.

It will save its price, besides making a better job.

Made in all sizes from No. 6 to 500,000 C. M.

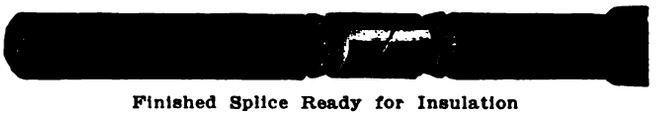
Made for A. C. or D. C. The A. C., a copper splicer, may be used on either A. C. or D. C., but D. C. splicers cannot be used on A. C.

To make the splice, cut the ends of the cable, then remove insulation from the ends for one or more inches, depending on size of cable, intermesh the ends.

Cable Prepared for Splicing

Splicing Tool Ready for Operation

Sectional View Showing Appearance of Wire Within the Splicer



Finished Splice Ready for Insulation

The splicer having been previously slipped over one end is now placed around the joint, then placed in the splicing tool and a few blows with a hammer completes the operation.

The Canton Bond Terminal

The bonding tool being light, one man can carry his tools and do the work. Most methods require a helper.

Needs no trained, high priced mechanics, as required with welding processes. Any intelligent person with the "Canton" bonding tool can make a satisfactory bond.

The bond can be made any desired length and placed under or over the splice bar. It is not affected by vibrating rail joints nor derailed cars. The old copper wire and cables which accumulate about the mines can be utilized.

Requires no soldering nor heat. Gaseous mines present no difficulties in installation. Can be quickly installed.

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THE OHIO BRASS COMPANY

MANSFIELD, OHIO

50 Church St., New York 2205 Oliver Bldg., Pittsburgh 343 S. Dearborn St., Chicago
Charleston Electrical Supply Co., Charleston, W. Va.

Products:

Mine Trolley Hangers; Trolley Clamps; Trolley Wire Splicers; Trolley Wheels and Harps; Compressed Terminal and Electric Weld Rail Bonds; Bonding Tools; Electric Welding Machines; Trolley Frogs; Trolley Cross-overs; Feeder Wire Insulators; Strain Insulators; High Tension Insulators; Section Insulator Switches; Expansion Bolts, etc. These are described and listed in our General Catalog. We also make a complete line of Brass Valves listed and described in our Valve Catalog. Separate bulletins describe Crouse-Hinds Imperial Luminous Arc, Carbon Arc, and Incandescent Headlights for which we are exclusive sales agents in the United States. Copies of any or all of these catalogs sent on request.

O-B Mine Section Insulator Switches

Opened or closed without stopping. Soft rubber handle protects user.

O-B Type M Section Insulators (Patented)

Open, switch completely insulates the two sections. Closed, there is a smooth all alive, all metal underrun.

Two sizes Type M-1. One size Type M-2. Trolley wheel can run through Type M-2 when switch is open.

O-B Trolley Clamps (Patented)

Retain their unyielding hold on the trolley wire in spite of heavy strains. Rugged enough to meet the most severe conditions.

Have plenty of trolley wheel clearance. Made for all sizes of round, grooved and Figure 8 wire.

O-B Wedge.

O-B Bulldog.

O-B Mansfield.

O-B Premier.

O-B Trolley Wheel and Harp (Patented)

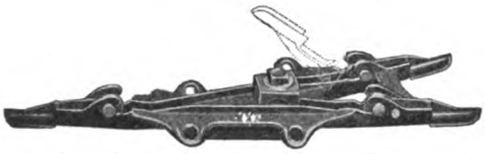
Wheel is made of high quality bronze.

Wearing surfaces extra thick. Furnished with Graphite Bushing and large reservoir filled with grease.

Harp is especially designed for mining service. Pivot, set forward of the wheel axle gives trailing action so that harp easily follows irregularities in the trolley wire.

O-B Trolley Wheel and Harp (Patented)

O-B Type D Trolley Frog (Patented)



Has only six parts including Renewable Cam Tips.

Installed easily and quickly.

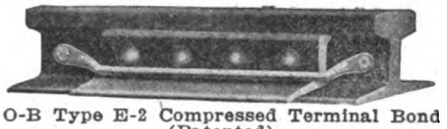
Strong and sturdy for severe service.

O-B Rail Bonds

O-B Rail Bonds reduce resistance in the return track circuit, and so speed motors, prevent motor trouble and save power.

O-B Type AW-7 Arc Weld Bond—Patented. Also made for ball of rail.

O-B Arc Weld Bonds have certain essential features which simplify installation and lengthen their life. Applied with any arc weld machine. O-B Resistance Machines have unusual safety, control and convenience features.

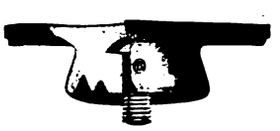


O-B Type E-2 Compressed Terminal Bond (Patented)

O-B Compressed and Pin Driven Terminal Bonds are made in all sizes and capacities for every service.

O-B Mine Trolley Hangers

Made in various designs for different conditions.



Timber

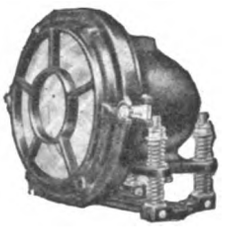
Universal

Roof

Dirigo insulation is used in these hangers. Its electrical and mechanical strength is remarkable.

Crouse-Hinds Imperial Headlights

Luminous Arc, Type MLK
Maintains Intense Light on Varying Voltage



Incandescent
Type MH
Entire Headlight Cushioned by Eight Stiff Springs

Two designs from a complete line of rugged headlights for mine locomotives.

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THE O. H. DAVIDSON EQUIPMENT CO.

1633 Tremont Street, DENVER, COLORADO

Main 6350

Manufacturers' Representatives

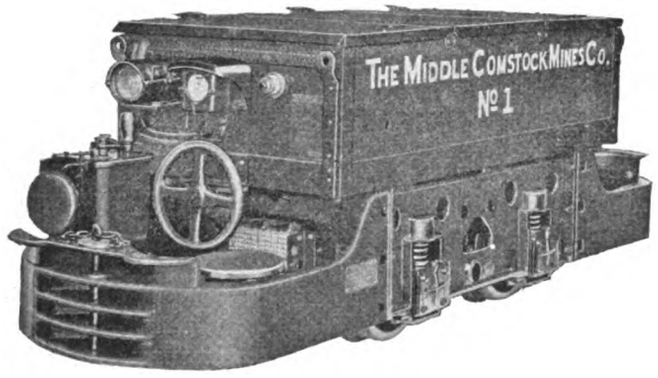
Electrical and Metal Mining Equipment and Supplies

Products

Arc Welders; Storage Battery Locomotives; Rail Bonds; Robertson Process Metal, Ventilators and Skylights; Cages; Cagers; Mine Cars; Roller Bearing Trucks; Rope and Trolley Clamps; Mine Hangers; Trolley Line Material; Portable Mine Pumps; Steel Mine Ties; Motors, Generators and Transformers; Manila and Wire Rope and Fittings; Trolley Frogs; Lamp Guards; Trolley Harps; Sure Grip Clamps; Turnbuckles; Tackle Blocks.

Storage Battery Locomotives

The Mancha Storage Battery Locomotives, specially designed for metal mines, are revolutionizing haulage methods. They increase hauling distances even over grades that make hand tramming im-



Titan A. X. Type. One of three types in sizes 1½ to 4½ tons. Gauges 14 inches up.
See page 339 for further particulars.

practicable, eliminating sinking of additional shafts. Greater loads can be hauled more rapidly and cheaply than with trammers or mules. The Mancha Locomotive is a self-contained unit, carrying its own source of power wherever it goes, without the use of trolley or cables. Our engineers will be pleased to examine your conditions and recommend suitable equipment.

Electric Motors and Transformers

Wagner alternating current motors, generators and transformers are especially suitable for mining and milling conditions. Stocks of motors and transformers in Denver permit quick delivery and dependable service.

Mine Cars and Trucks

We sell Enterprise Improved Roller Bearing Trucks on an absolute five-year guarantee. Our factory in Denver manufactures every type of steel or wooden mine car. We will be glad to submit designs of any special cars desired.

Mine Ties and Pumps

Ask us for descriptive matter on Fairmont Steel Mine Ties and Portable Mine Pumps.

Building Materials

In the mining and milling field unusual conditions exist which necessitate the use of a building covering that will successfully resist severe weather, smoke, gases, fumes and condensations. The Robertson Process Metal will meet these adverse conditions and give you a building covering at less cost and with attractive appearance and long life. Ask for catalog and samples.

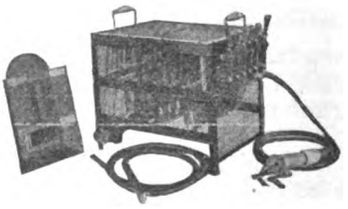
Robertson Ventilators and Skylights are also particularly adapted to mining and mill use.

Trolley Line Material

Representing The Electric Railway Equipment Company, manufacturers of a complete line of overhead Mine Hangers, Sure Grip Clamps, Trolley Frogs, etc. Catalog supplied on request.

Arc Welding Outfits and Rail Bonds

Erico Arc Welding Equipment solves the rail bonding problem and also takes care of general, track and shop welding.



250 Volt Mine Outfit.

Erico Arc Weld Bonds are easily and cheaply installed with this welder.

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THE ALDON COMPANY

3338-40 Ravenswood Ave., CHICAGO, ILL.

Manufacturers of

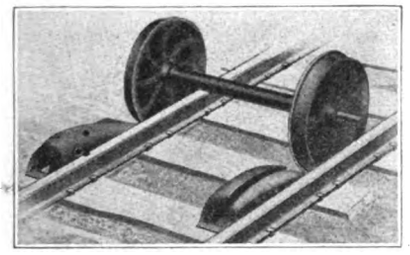
Car Replacers, Rail Benders, Rail Saws, Track Drills, Car Movers, Track Gauges, Track Levels

Aldon Car Replacers

Aldon Car Replacers are of the single end, wedge shaped type, providing a gradual incline to the rail. They are built upon the principle of a rail switch in that they positively lead the wheels

Aldon Car Replacer

to the rails. They do not depend upon gravity. The pressure on the frogs being straight downward until the wheels are suspended over the rail, they will not kick out of place. With these Replacers the wheels cannot climb over the frogs; they must go to the rail. They are especially designed to clear low hung locomotives and cars.



Aldon Car Replacer in Use

One right and one left are a pair.

They are made in five sizes, as follows:

No. 1—Cast Steel, weight 200 lbs. per pair, suitable for heaviest equipment and for 100 lb. rails.

No. 2—Cast Steel, weight 180 lbs. per pair, suitable for modern equipment and for 85 lb. rails.

No. 3—Malleable Iron, weight 100 lbs. per pair, suitable for light equipment and for 70 lb. rails.

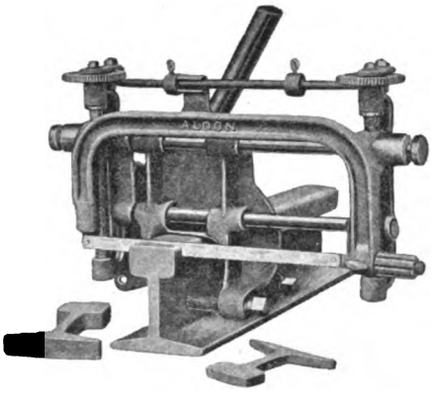
No. 3½—Malleable Iron, weight 100 lbs. per pair, suitable for light equipment and for 50 lb. rails.

No. 4—Malleable Iron, weight 55 lbs. per pair, suitable for light equipment and 35 lb. rails.

Our No. 4 is our regular Mine Car Replacer.

Aldon Rail Saws

Aldon Portable Rail Saw is a hand operated machine, designed to easily and accurately cut rails in or out of the track. It provides a clean straight cut, and will not break the blades. It is attached over the top of the rail, thus it is not necessary to



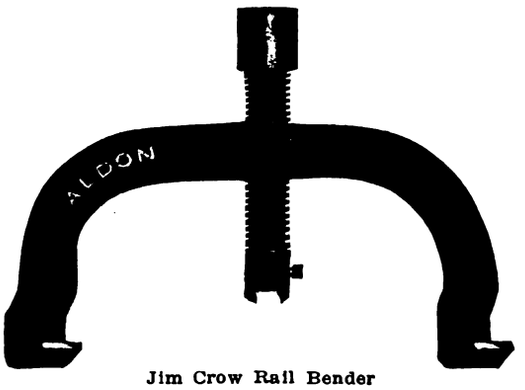
Aldon Rail Saw

disturb the track ballast or fastenings. Its feed is automatic with the movement of the handle, and is variable and adjustable. All wearing parts are bronze bushed, providing for long wear. The machine weighs but 55 lbs. and is easily portable. It will fit any T-rail 6 inches or less in height, and will slice off pieces of rail ⅛″ in thickness if desired. It is a great time and labor saver when laying new track.

Aldon Rail Benders

Jim Crow Rail Benders for all size rails.

These benders are forged from solid machine steel and have machine cut square screws.



Jim Crow Rail Bender

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American Car and Foundry Company

General Offices

NEW YORK CHICAGO ST. LOUIS

ORE CARS

Products

Railway coach, dining and sleeping cars. Express, baggage and mail cars. Electric railway cars. Freight cars, including box, flat, gondola, hopper, dumping and tank types and cabooses. Special purpose cars for carrying cane, livestock, etc.

ORE CARS of all types and capacities, coal cars, industrial and logging cars.

Chilled iron wheels: Plain, self-oiling and roller bearing mine car wheels; freight car, dump car and mine locomotive wheels. New wheels mounted on old axles or replacements made in exchange for old equipment.

Gray iron castings: Light and heavy castings of all descriptions for cars, locomotives, and mines; also building and mine columns.

Cast iron flange pipe and fittings; bell and spigot fittings.

Merchant bar iron: Refined and extra quality iron in rounds, squares, and flats.

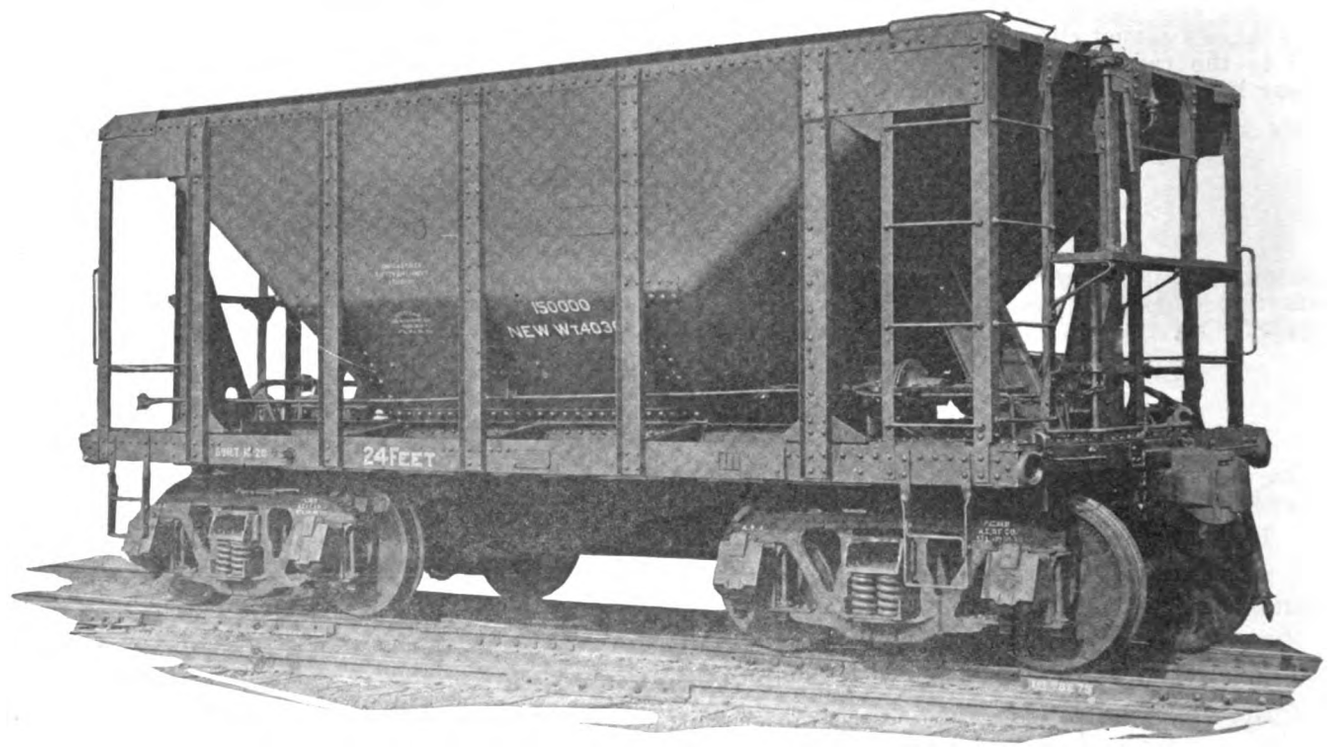
Merchant Forgings: All kinds of freight, passenger and mine car forgings, bent and punched plates, and forgings for general trade.

Axles: All sizes, steel and iron. Particular attention paid to axles for small cars. Heat-treated axles a specialty.

Car parts, including bolsters, journal bearings, brake beams, arch bars, couplings, iron and woodwork complete, and for any part of freight, passenger and miscellaneous cars. Car trucks for any class or capacity of cars.

Iron body gate valves; bolts, nuts and rivets.

Berwick Electric Rivet Heater.



75-TON STEEL ORE CAR

Capacity 150,000 Pounds or 900 Cubic Feet Level Full

Length over end sills	21′ 3¼″
Length inside	19′ 10 ″
Width over side sills	9′ 10½″
Width inside	9′ 9¾″
Height from rail to top of sides	10′ 2 ″

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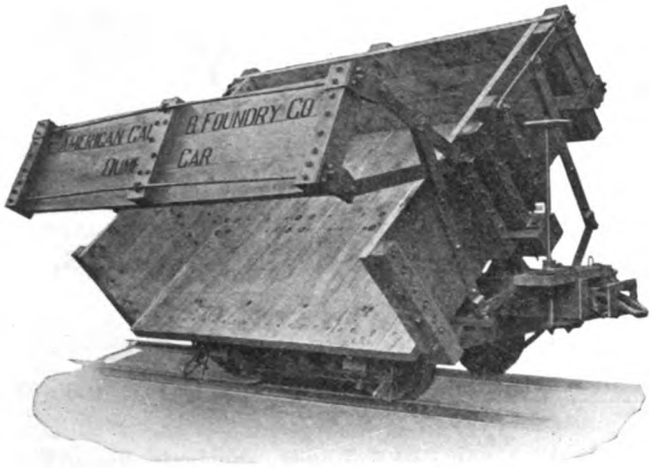
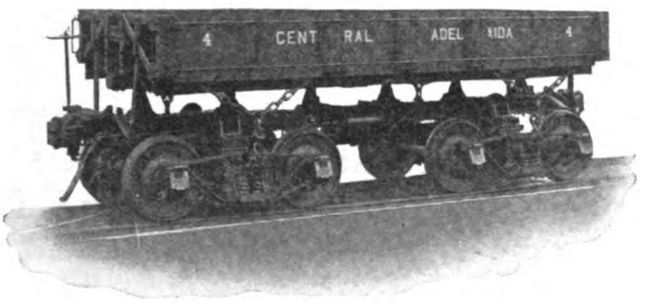


A. C. & F. Co. Standard Two-way Dump Car

Length, over all—12 feet 6 inches.
Width, over all—7 feet 7 inches.
Height, over all from top of rail—5 ft. 7¼ in.
Length, inside—8 feet 3 inches.
Width, inside—6 feet 6 inches.
Height, inside—2 feet 0 inches.
Wheel Base—4 feet 0 inches.
We make these cars of all sizes and capacities.

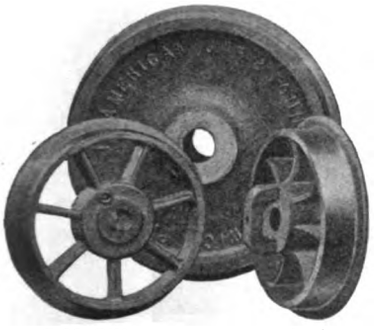


Steel Underframe Two-way Dump Car

50,000 pounds capacity.
Length, over end sills—21 feet 2 inches.
Length, inside—18 feet 0 inches.
Width, over side sills—7 feet 1½ inches.
Width, over all—8 feet 9½ inches.
Height, rail to top of car—6 feet 11½ inches.
Truck, Wheel Base—5 feet 4 inches.

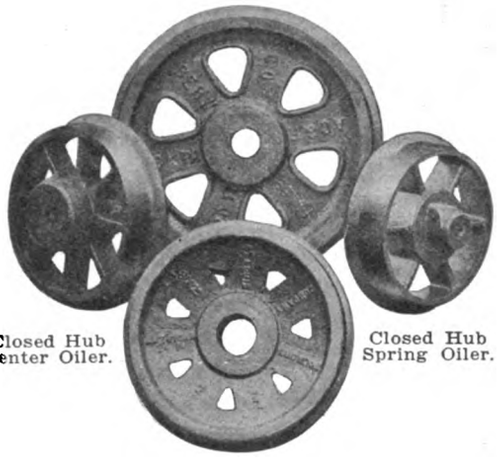
CHILLED IRON WHEELS

Plate Type Motor.



Self Oiling Open Hub. Arch Oiler.

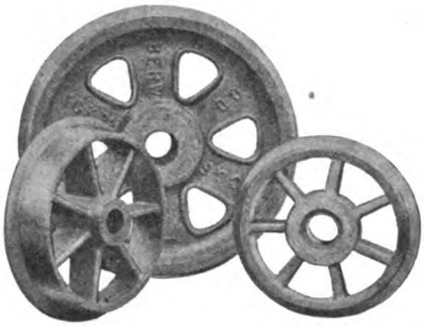
Spoke Type Motor.



Closed Hub Center Oiler. Closed Hub Spring Oiler.

Spoke Type Street Car.

Spoke Type Motor.



Plain Hub. Plain Counter Bore.

Standard and special designs of chilled iron wheels for all types of mine equipment. Plain or self-oiling; open or closed hub; closed hub with visible linch-pin; roller bearing type and motor wheels.

The standard wheels throughout the world are chilled iron. Naturally, the accepted standard is our specialty, with the added improvements which many years of manufacturing experience have developed. Our own formula for wheel mixture assures long life as the result of excellent wearing qualities.

Foundry capacity 12000 to 15000 wheels per month.

Excellent facilities for refitting new wheels on old axles.

Our Engineering Department is at your disposal.

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BAKER CAR COMPANY

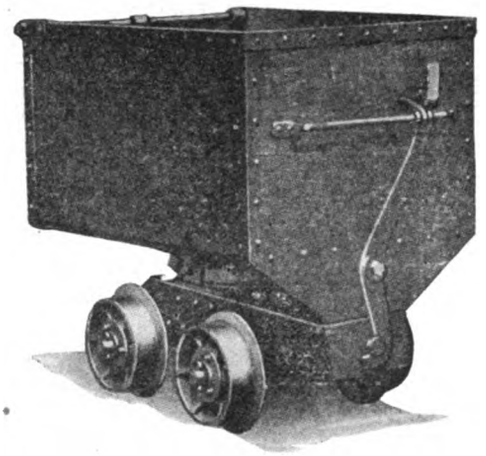
HARRIMAN, TENNESSEE

Manufacturers of

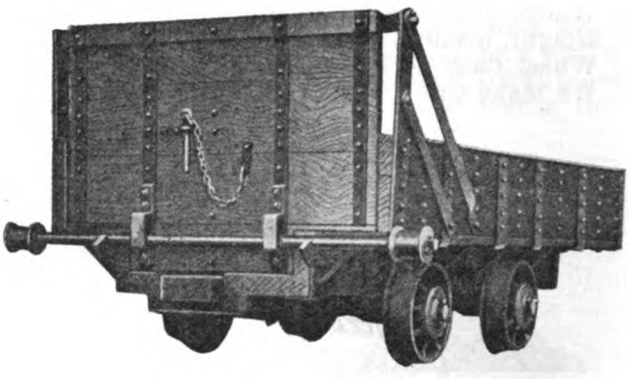
Cars, Trucks, Motor Wheels, Sheave Wheels, Incline Rollers, Sand Driers, Etc.

Products

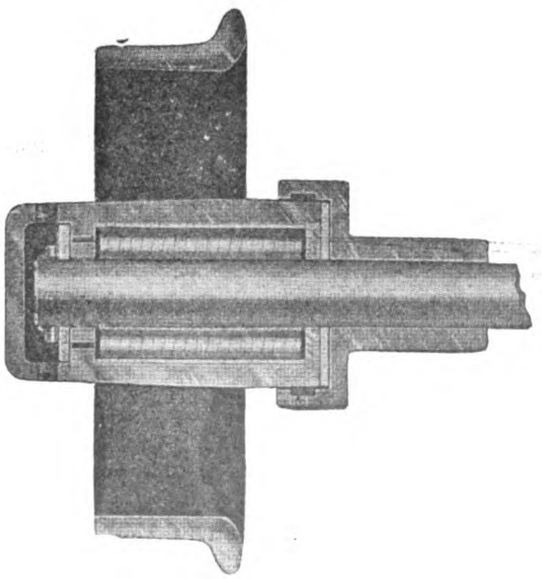
Cars for All Classes of Mining Work, Quarry Cars, Industrial Cars, Trucks, Motor Wheels, Sheave Wheels, Incline Rollers, Sand Driers, etc.



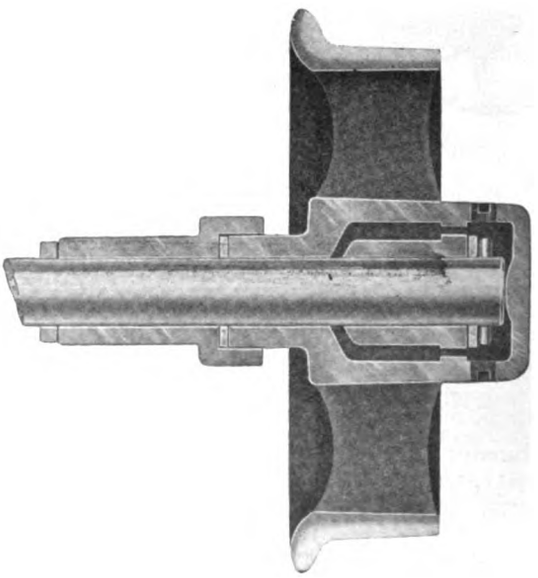
One Type of Car for Use in Ore Mines



One Type of Quarry Car. These Cars Can Be Made of Wood or Iron, or of Wood and Lined with Steel Plate.



Style C Roller Bearing Wheel Equipped with Hyatt Flexible Bearing



Style C Self-Oiling Wheel

We have various wheel patterns to select from and we can build cars to your specifications.

WE SOLICIT YOUR INQUIRIES

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EASTON CAR & CONSTRUCTION CO.

Main Office and Works
37 Holley St., EASTON, PA.

Branches		Branches	
NEW YORK	CLEVELAND	SPARTANBURG	SALT LAKE CITY
BOSTON	DETROIT	ATLANTA	DENVER
PHILADELPHIA	CHICAGO	DALLAS	LOS ANGELES
PITTSBURGH	ST. LOUIS	KANSAS CITY	

QUARRY CARS--FROGS--SWITCHES--RAILS

Products

Quarry Cars; Frogs; Switches; Rails.

The illustrations given here show only five typical Easton Quarry Cars.

We build a great many different types for all kinds of quarry work.

The fine service rendered by them under severe operating conditions is an indication of their correct design and excellent construction.

"Quarry Car Practice," a profusely illustrated study of quarry cars and their use, published serially in Bulletin form, will be sent on application.

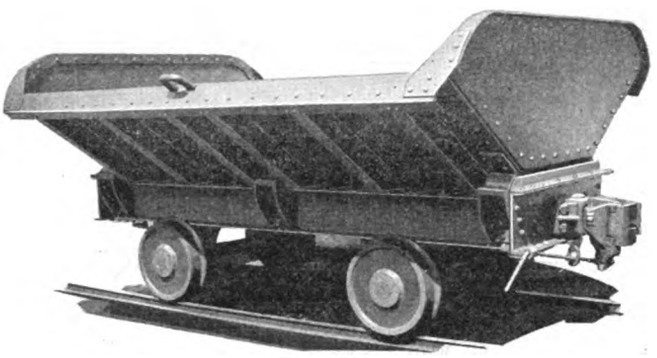

Fig. 5794

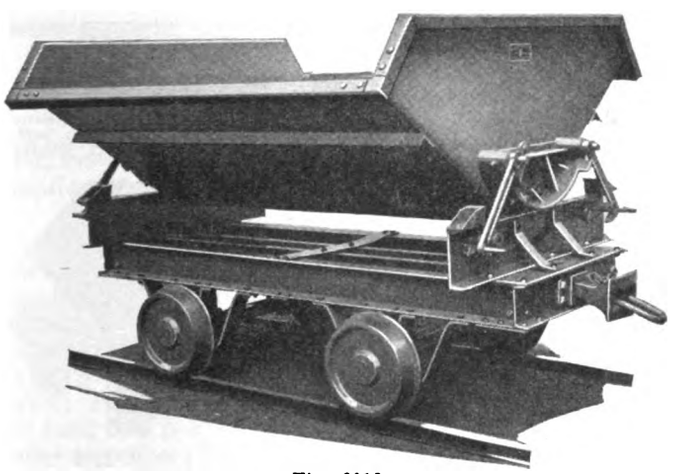

Fig. 6013

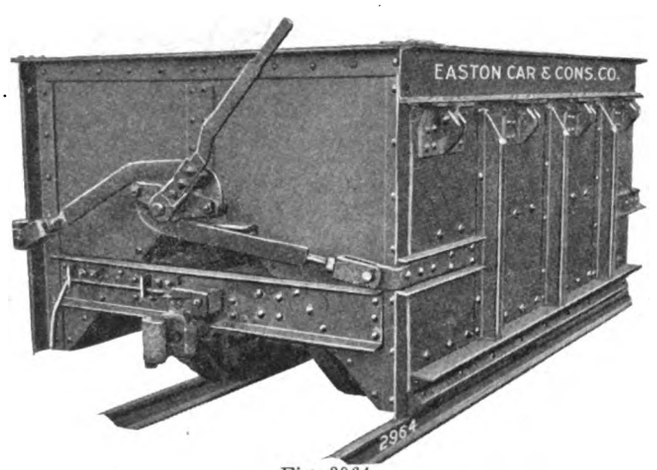

Fig. 2964

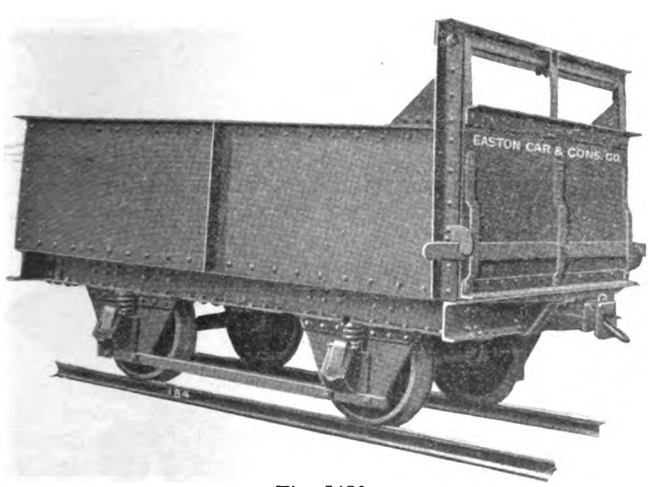

Fig. 5476

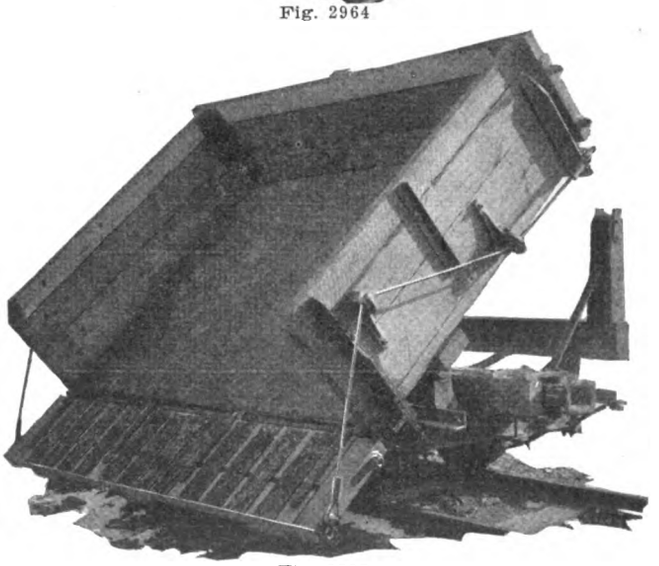

Fig. 5597

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JOSHUA HENDY IRON WORKS

ESTABLISHED 1856

General Office

61-75 Fremont Street, SAN FRANCISCO, CALIFORNIA

Works—Sunnyvale, Santa Clara Co., California

Manufacturers of

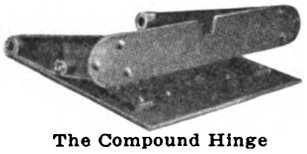
Mining, Industrial and Construction Machinery

Products

Car Building Division—Mine Cars, Ore and Quarry Cars and Skips of every description; Chilled Car Wheels; Logging and Plantation Cars; Trucks, plain and roller bearing; Industrial Cars for every purpose; Buckets; Sheaves; Turntables; Frogs and Switches.

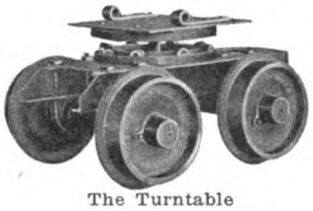
For other products see pages 401, 528, 529, 630 and 631.

"Matteson" Mine Car Features

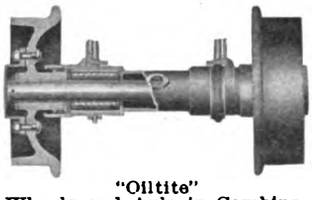


The Compound Hinge

Hendy's "Dust Proof" Axle and Plain Bearing



The Turntable



"Oiltite" Wheels and Axle in Combination with "Hyatt" Flexible Roller Bearings. Not supplied unless specified.

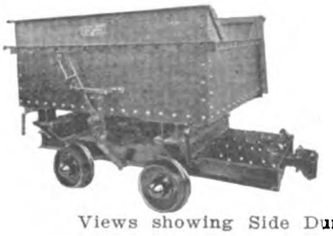
The illustrations above show a few of the distinctive features that make them different from all other ore and rock cars.

"Matteson" Type "E" Mine Car. Standard equipment, but with brakes and bar coupling.

Light Railway Car

Bucket Car

Stake Car



Views showing Side Dump Car—Heavy type.

"Matteson" Type "D" Mine Car, Automatic Door Latch Device.

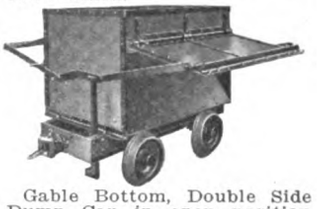
Same as Type "D" to left, but fitted with Hyatt Roller Bearings.

"Matteson" Type "E" Mine Car

"Matteson" Type "E" Mine Car. Same as shown to left, but fitted with Hyatt Roller Bearings.

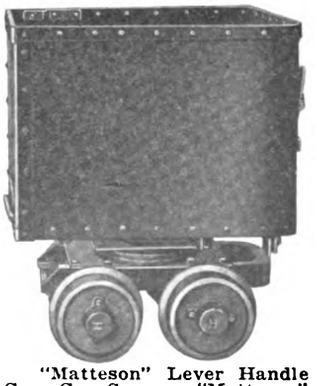
"Matteson" Steel Frame Automatic Side Dump Car. Fitted with automatic rail grab and draw heads.

"Matteson" Steel Frame Automatic Side Dump Car. Same as car to left but fitted with Hyatt Flexible Roller Bearings.



Gable Bottom, Double Side Dump Car in open position showing gable bottom.

Hendy's Ideal Car. An either way or double side dump "V" shape body car.



"Matteson" Lever Handle Cage Car. Same as "Matteson" Type "E" Car, but with vertical front and back.

"Matteson" Scoop Car. Designed for handling wet materials.

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KENOVA MINE CAR COMPANY

Factory and Office: KENOVA, W. VA.

Machinists

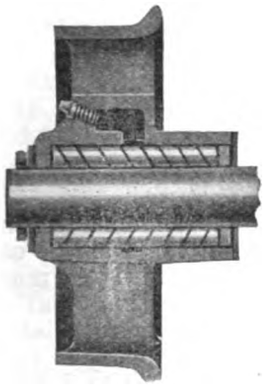
Trade Mark Registered

Founders

Engineers

Products

Wood, Steel and Composite Mine Cars; Quarry and Ore Cars; Industrial Cars; Trucks; Plain and Roller Bearing Wheels; Axles; Car Irons; Castings; Car Accessories.



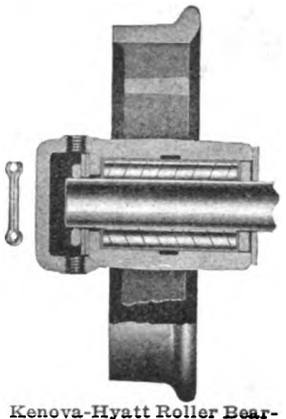
Kenova-Hyatt Roller Bearing, Exposed Linch Pin Type

The Car

Every part of a Kenova Car is made to a template, insuring perfect fit and interchangeability. Kenova Cars represent the most advanced car engineering, and are built of the best materials, and by the finest workmen obtainable. They are as nearly fool-proof, trouble-proof and as low in cost per mile as can be built. Kenova Cars have but one quality—The Best Kenova Can Put Into Them.

The Truck

Our standard wheel designs are as illustrated. Special designs may be made to cover special conditions.

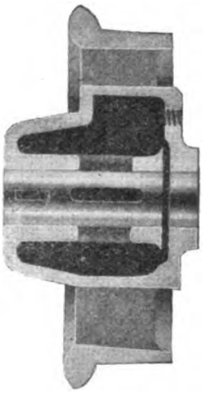


Kenova-Hyatt Roller Bearing, Closed End Type

Wheels are cast in our own foundry, in accordance with the most scientific and latest approved foundry practices. They carry a deep, uniform chill and are carefully annealed. On our standard truck we use cold rolled open hearth steel axles, .40-.50 carbon. The truck is held to a perfect track gauge through the use of a steel channel plate, bolted to the journal boxes. It is held to a perfect wheel base through the use of an inside and an outside steel tie strap. It should be noted that our standard plain and roller wheels are interchangeable.

Prices

Kenova Cars are not high priced when quality is considered. It is more economical to be permanently pleased with long and reliable service, than it is to be temporarily pleased with mere low price—and then have to worry along with the article's shortcomings.



Self-Oiling Wheel, Plain Bearing

Deliveries

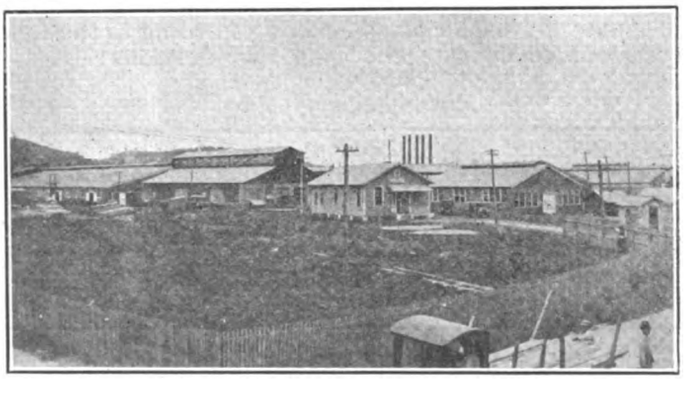
Our plant has the greatest capacity of any similar plant in the country. Hence, we are in a position to offer excellent deliveries.

Guarantee

Kenova Trucks carry an unqualified guarantee. We are back of every car we build until the day the buyer is satisfied. We're behind our product without reservation.

Engineering Service

We maintain an engineering service that is yours to consult. This will not obligate you in any way.



The one sure way to know car values is through investigation. Kenova Cars face any comparison, and show extra values.

Let Us Estimate Upon Your Requirements.

Next Time—

Buy Kenovas

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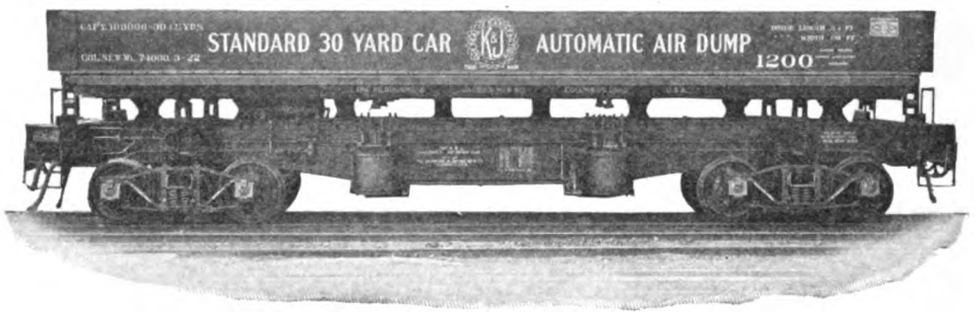
The Kilbourne & Jacobs Manufacturing Co.

Executive Offices: COLUMBUS, OHIO

NEW YORK—120 Broadway

Manufacturers of

Automatic Air Dump Ore Cars



"K & J" All Steel Automatic Air Dump Car, Capacity 30 Cu. Yds.
This Car is also made in level capacities of 16, 20, 25 and 33⅓ Cu. Yds.

General

The Kilbourne & Jacobs Manufacturing Co., Columbus, Ohio, is the originator and pioneer builder of automatic two way, air dump cars. Automatically controlled air dump cars, developed, designed and built by the company have been in wide use for over fourteen years and have withstood the heaviest service. They have been successfully employed on the Missabe Iron Range, in the western heavy metal mines and in the heaviest class of pit and quarry work.

At the present time these cars are extensively used in quarries, iron mines and copper mines as well as in general railroad construction and maintenance work and in various other industrial enterprises. Their design and construction is such as often to afford a practical means of effecting large economies in the rapid and safe handling of large quantities of bulky and refractory materials.

The "K & J" Dump Cars

The "K & J" Air Dump Cars are entirely automatic under all conditions. Operating air is drawn from a storage reservoir on each car. The reservoir is charged from the regular air brake train line and has a capacity sufficient to operate the loaded car two or more times independently of the locomotive. The operation of dumping a single car or any number of connected cars requires no more than 10 seconds. The complete operation, that of unlocking, dumping, and re-locking is accomplished by means of two simple levers, one for each side. When the car is in the dump position, the door is elevated in a plane parallel with the floor, thus giving full dumping clearance. Trains may be operated from any connected car, and cars may be dumped all to one side, alternate cars to opposite sides, or any connected section to one side and the remaining to the other.

The "K & J" cars conform to the practice recommended by the Master Car Builders' Association and meet the requirements of the Interstate Commerce Commission. Those most widely used are Model R-20, Model R-30 and Model C-16, having capacities of 20, 30 and 16 cu. yds., respectively, when level full. They are made according to the following specifications:

TRADE MARK
THE SEAL OF SATISFACTION K&J
REG. U.S. PAT. OFF.

"K & J" All Steel Automatic Air Dump Cars are covered by patents as follows:

872,057—Nov. 26th, 1907.
907,218—Dec. 22nd, 1908.
921,376—May 11th, 1909.
973,229—Oct. 18th, 1910.
1,029,247—June 11th, 1912.
1,034,418—Aug. 6th, 1912.
1,057,413—Apr. 1st, 1913.
1,178,208—Apr. 4th, 1916.
1,236,368—Aug. 7th, 1917.
1,281,508—Oct. 15th, 1918.
Other patents pending.

	Model R-20	Model R-30	Model C-16
Capacity	80,000 lbs.	100,000 lbs.	**60,000 lbs.**
Angle of dump	45 degrees	45 degrees	**45 degrees**
Length over couplers	32 ft. ½ in.	40 ft. 3 in.	**30 ft. ⅛ in.**
Maximum width	10 ft. 2 in.	10 ft. 6 in.	**10 ft. 2 in.**
Center to center of truck	19 ft.	26 ft.	**16 ft.**
Top of rail to top of body	8 ft. 5½ in.	8 ft. 10⅞ in.	**7 ft. 10½ in.**
Approximate weight	52,000 lbs.	74,000 lbs.	**46,200 lbs.**

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LAKE SHORE ENGINE WORKS

MARQUETTE, MICHIGAN

Manufacturers of

Mining and Industrial Cars

Products

A complete line of all steel mine cars of all sizes and capacities, including Rock Cars, Rotary Dump, etc.; Rotary Car Dumpers; Cast Iron Car Wheels, Plain and Roller Bearing; Car Trucks; Mine Cages and Skips; Skip Safety Devices; Water Bailers; Rope Sheaves. For other products, see Pages 402, 403 and 415.

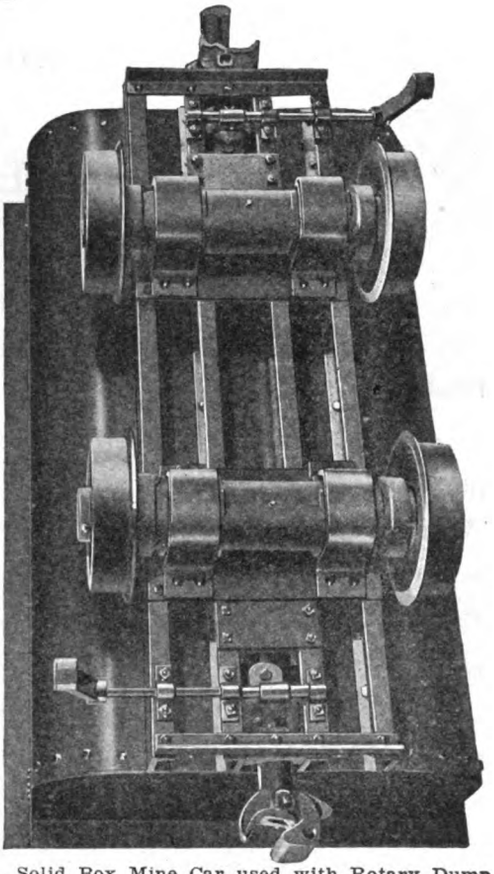
Mine Cars

Our line of mine cars is so large and of such great variety that it is only possible to illustrate here a few of our stand- and types. However, we can furnish cars to meet all conditions of service, as to capacity, track gauge, method of dumping, etc., and will cheerfuly send catalog and full information upon receipt of data as to your requirements.

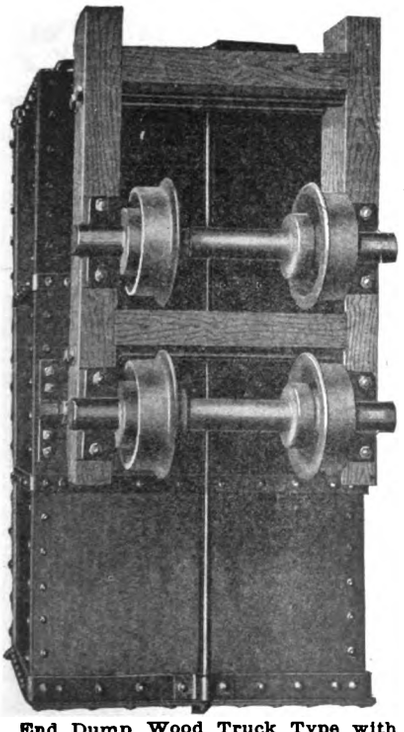
Mine Car Trucks

Hyatt Roller Bearings are standard equipment for our roller bearing cars. This makes a self-contained unit; rollers cannot drop out when wheel is removed from axle; 50% less power is required to move a car; ideal lubrication is assured.

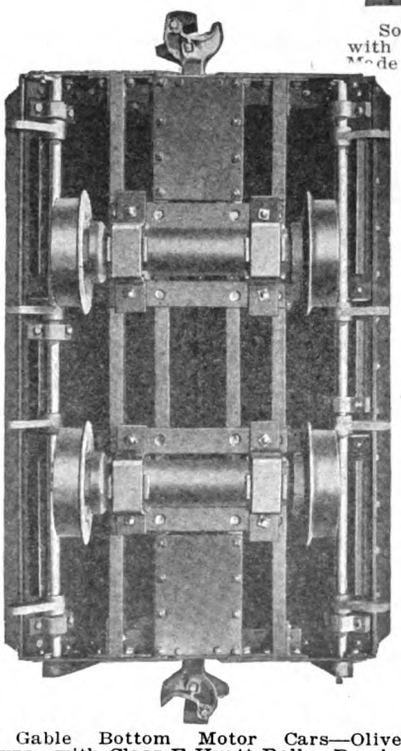
These cars are completely described in our general car catalog furnished on application.



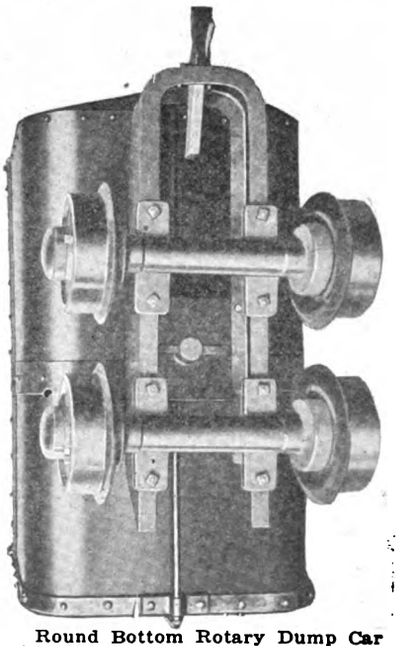
Solid Box Mine Car used with Rotary Dump with Class F Hyatt Roller Bearing Trucks. Made in 42, 55 and 65 cu. ft. sizes. Can be used with Car-Dumper & Equipment Company's Rotary Dumper. See Pages 410 and 411.



End Dump Wood Truck Type with Class H Hyatt Roller Bearing Trucks. Made in 30 to 50 cu. ft. sizes.



Gable Bottom Motor Cars—Oliver Type—with Class F Hyatt Roller Bearing Trucks. Made in 35, 45, 55 and 65. cu. ft. sizes.



Round Bottom Rotary Dump Car with Class E Hyatt Roller Bearing Trucks. Made in 12 to 32 cu. ft. sizes.

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LOBDELL CAR WHEEL COMPANY

Established 1836

WILMINGTON, DELAWARE

Steel and Iron Founders and Machinists

Products

Car Wheels of every description, complete running gear for Mine and Quarry Cars, Locomotive Wheels, Axles and Tires; Refitting and Repairing a Specialty; Iron and Steel Castings.

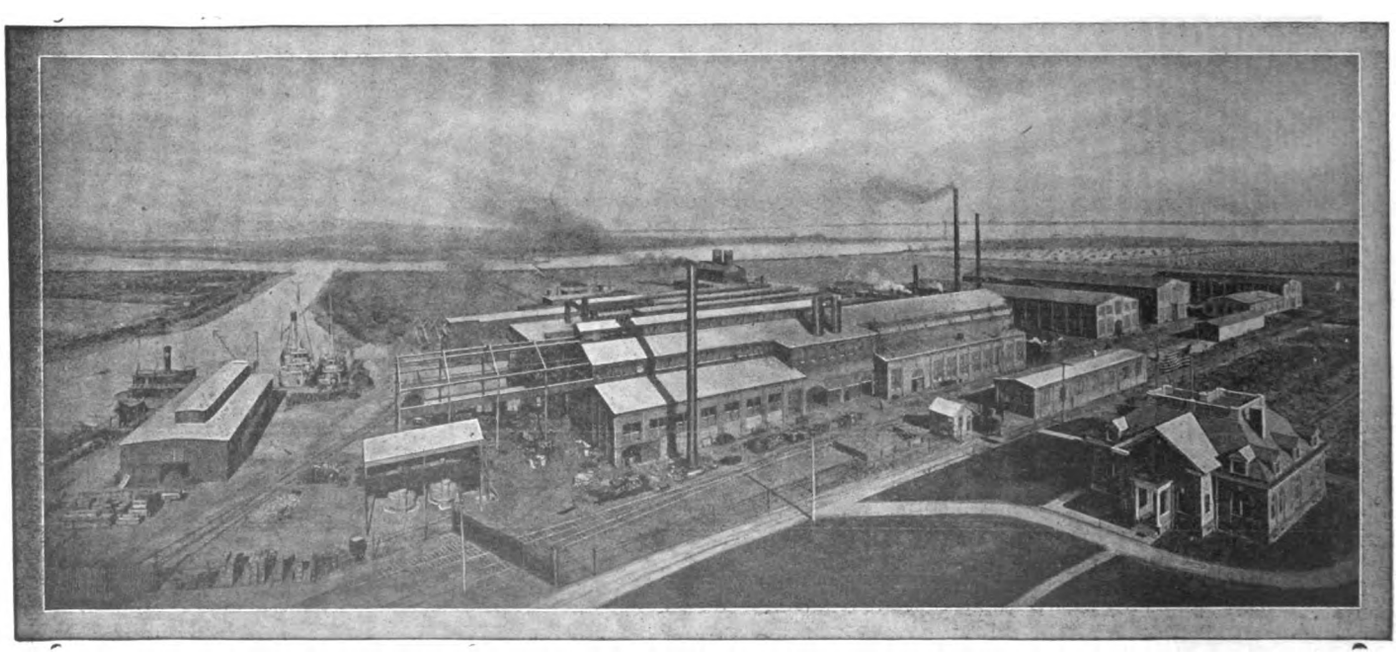
For almost 85 years this company has concentrated on the manufacturing of car wheels and allied articles of chilled iron and steel, and has today the largest and best equipped plant for this class of work in this country.

We are equipped with over 500 patterns for wheels of different sizes and kinds of service, with patterns for various kinds and sizes of journal boxes, with complete machine equipment for fitting wheels and axles, and similar machine work.

We also make Special High Carbon Chrome Alloy Steel Castings and Chilled or Hard White Iron Castings for conveying and crushing machinery and the like.

We invite your inquiries and an opportunity to SERVE.

OUR WATCHWORD IS SERVICE



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OGDEN IRON WORKS COMPANY

Works: Ogden, Utah Main Office: Ogden, Utah

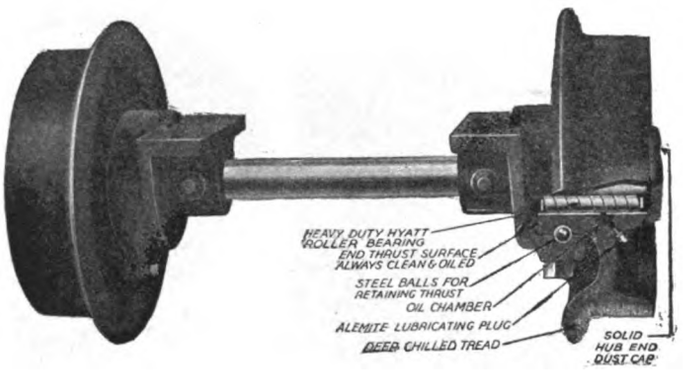
Mine Car Manufacturers

MINE CAR TRUCKS

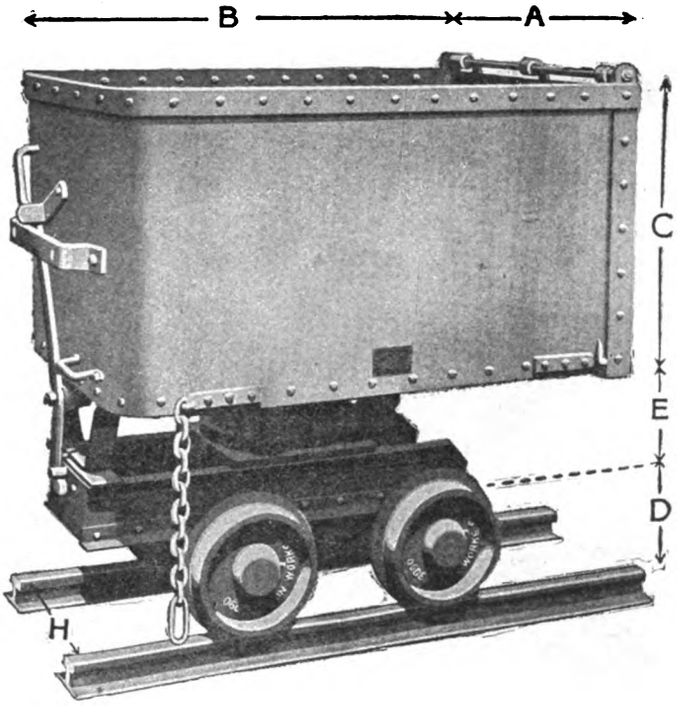
Diameter of Wheel	Diameter of Axle	Load Capacity at 5 Miles, Per Hr.	Price of Truck
10″	1½″	3200 lb per truck	$36.00
*10″	1 11/16″	5000 lb per truck	38.00
12″	1½″	3200 lb per truck	42.00
*12″	1 11/16″	5000 lb per truck	44.00
12″	1 11/16″	5000 lb per truck	52.00
*12″	2 11/16″	10000 lb per truck	62.00

*Solid Roller Bearings instead of Hyatt Bearings.

NOTE—Each truck is the running gear of a car and thus consists of four wheels with roller and thrust bearings, two axles and four retaining collars.

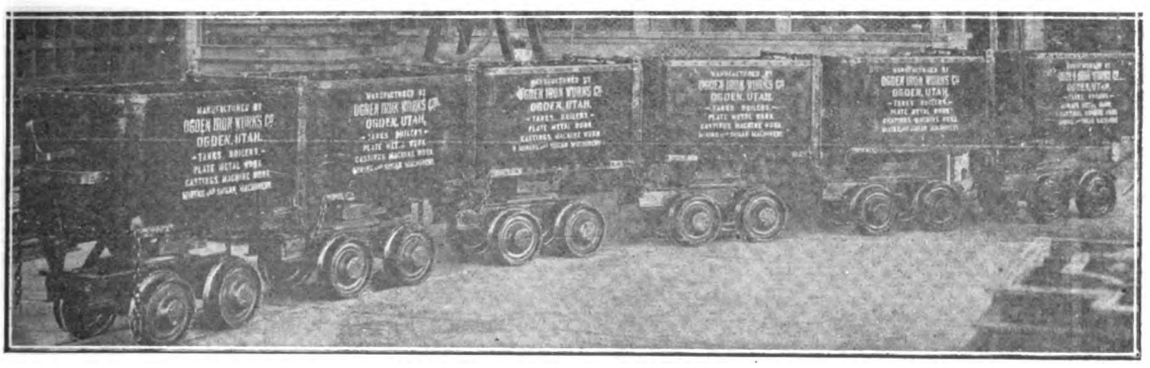


MINE CARS



Dimensions of Cars A	B	C	D	E	H	Weight Complete, Pounds	Price of Car	Capacity, Cu. Ft.
26″	42″	26″	10″	9¼″	18″	740	$110.00	17
30″	44″	24″	10″	9¼″	18″	750	110.00	18
30″	44″	24″	12″	8¼″	18″	1000	135.00	18
28″	45″	26″	12″	8¼″	18″	1000	140.00	19
30″	54″	24″	12″	8¼″	18″	1100	160.00	23

These cars are equipped with style of truck shown above, having roller bearing radial and ball bearing thrust load features and are provided with universal turntables and rotary dump, rigidly built bodies. Bodies are fitted with heavy bumper beams and coupling chains.



Silver Mine Cars (Patented April 9, 1918—Other Patents Pending)

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SANFORD-DAY IRON WORKS

Main Office and Factory: KNOXVILLE, TENN.

Makers of

Super-Mine Cars, Automobile Type, with Whitney Wonder Roller Bearing Wheels and Floating Axles

Fig. No. 3A-4. Rotary Car.

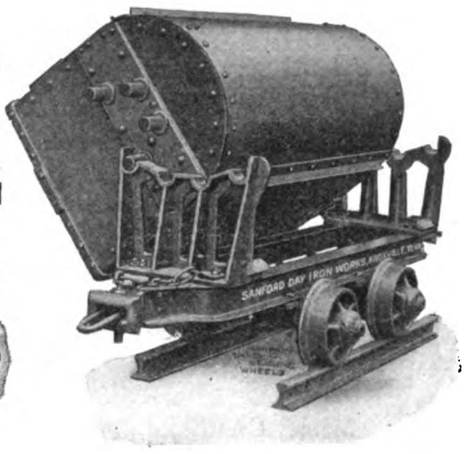

Fig. No. 7B-4. Side Dump

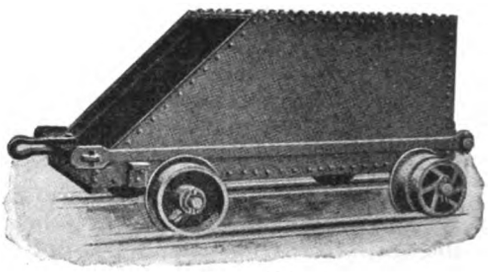

Fig. 11D-4. Skip Car.

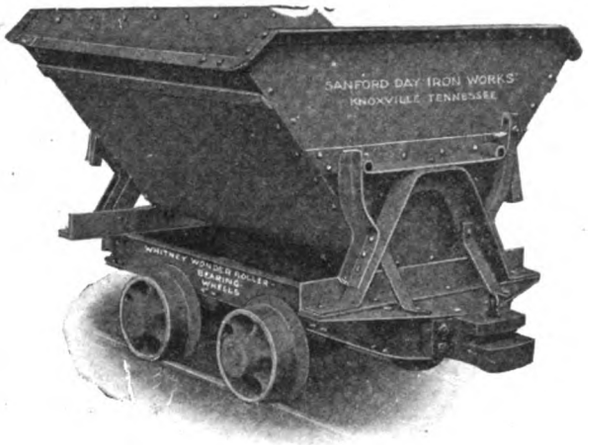

Fig. 14A-4. Rocker Side Dump.

Fig. 15A-4. Gable Car.

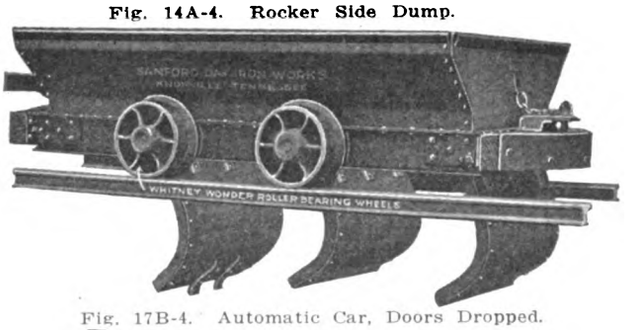

Fig. 17B-4. Automatic Car, Doors Dropped.

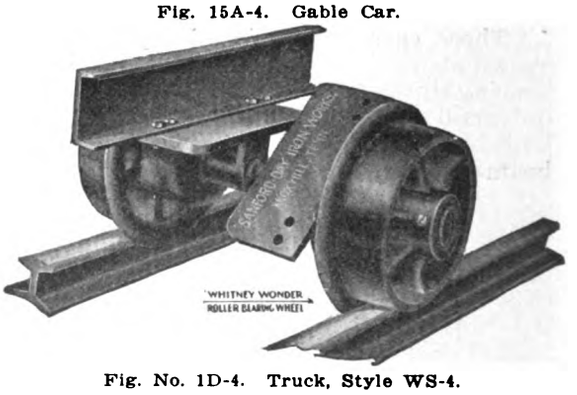

Fig. No. 1D-4. Truck, Style WS-4.

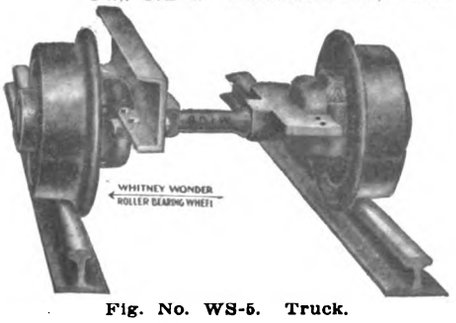

Fig. No. WS-5. Truck.

WHITNEY WONDER ROLLER BEARING TRUCKS—USED BY THE BIGGEST FELLOWS

Pictures Taken From Our Large Catalog 25-M

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SOUTHERN WHEEL COMPANY

General Offices, Railway Exchange Building, ST LOUIS, MO.
PLANTS AT ST. LOUIS, MO. AND BIRMINGHAM, ALA.

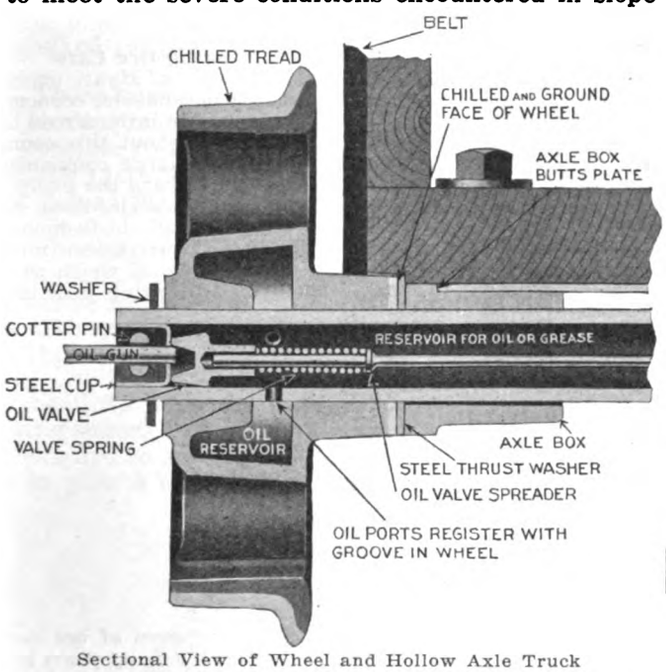
Mine Cars and Mine Car Trucks

Products

Mine Cars of Wood, Steel and Composite; Roller Bearing Mine Car Wheels; Plain Mine Car Wheels; Mine Car Axles; Hollow Axle Trucks for Mine Cars.

Hollow Axle Truck

The Hollow Axle Mine Car Truck was developed to meet the severe conditions encountered in slope



Sectional View of Wheel and Hollow Axle Truck

haulage mines where the speed of the cars will run from 1,800 to 2,400 feet per minute. Having proved successful under such severe conditions, it will meet the requirements of normal haulage systems.

Construction

The axle is made of .35 to .40 carbon cold drawn seamless tubing, having a hard bearing surface to resist wear, and an elastic limit of the steel of from 70,000 to 80,000 pounds per square inch, and a Brinell hardness of 170.

The HOLLOW AXLE has the least weight for a known strength or stiffness. Therefore, it gives the maximum of strength for the minimum of weight.

It permits of large bearing areas in the wheel to reduce wear, without increasing the weight of the axles.

Its hard, cold drawn surface, together with the improved oiling system, offers the greatest resistance to wear and reduces friction to a minimum.

Being hollow and of uniform diameter from end to end, it provides the most desirable form of reservoir for oil or grease, which is fed out of the axle into the wheels by gravity while the wheels are running.

There are no plugs, felts, rollers, cages, keys, blocks, etc., used in this construction; it can be lubricated without taking the car off the run with a grease gun, all wheels being oiled from one side of the car.

Inner face of wheel hub where it takes the thrust is chilled and runs against a steel washer, which, in turn, bears against the axle box. This type of thrust bearing is practically indestructible and will hold the wheel to its original gauge indefinitely and permanently and keep the wheel flanges from rubbing the sides of the car.

Advantages of the Hollow Axle Truck

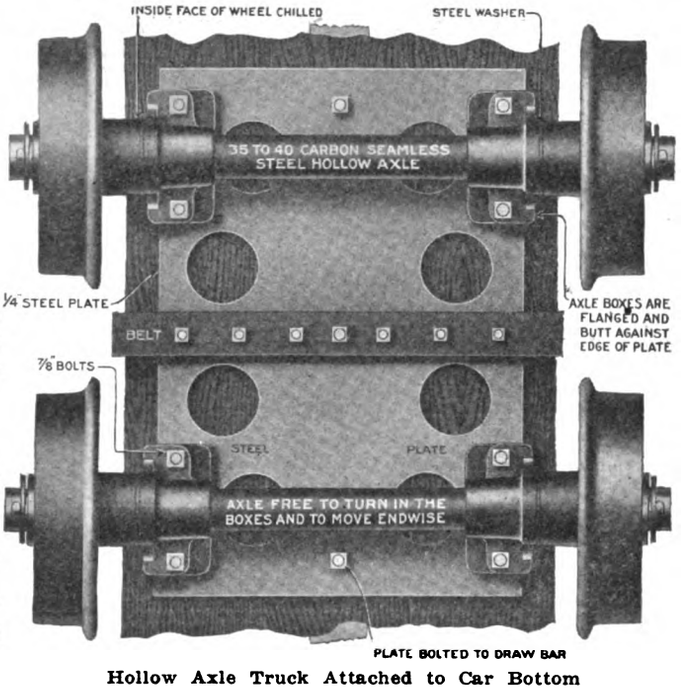
Greatest resistance to shocks per pound of weight. Will always run true and can not get out of square with the draw bar.

Axles always in line with each other; it is flexible and adjusts itself to uneven track.

Can be oiled or greased with a grease gun without screwing the gun into the wheel or without removing a plug.

A one-piece wheel, with extra large bearing area to reduce wear.

Axles have double the strength of solid axles, weight for weight.



Hollow Axle Truck Attached to Car Bottom

Not an Experiment

The first 100 sets of HOLLOW AXLE TRUCKS were put in service in August of 1914. There are now more than 12,000 sets in service, mostly in the coal and ore mines of Alabama. They are also operating successfully in Virginia, Kentucky, Illinois and Mexico.

In this wheel there is an absence of screwed plugs, caps, bolts, etc. The steel cup is pressed in tight, after which the cotter pin hole is drilled. Oil hole is 1½" back from end of axle, away from the dirt. Bearings are open for inspection. Wheel face has deep chill.

WRITE FOR LITERATURE.

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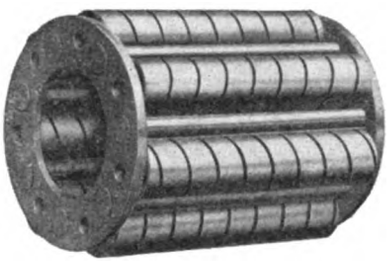
HYATT ROLLER BEARING COMPANY

NEW YORK, N. Y. and SAN FRANCISCO, CAL.

Hyatt Roller Bearings for Ore Cars

Why Hyatt Equipped Ore Cars Are a Good Investment

Ore cars equipped with Hyatt bearings effect large savings in power where mechanical haulage is used, cut lubrication costs, reduce upkeep of cars and locomotives; they make the trammers more willing to work because the cars push very easily and remove the back-breaking drudgery from their work. Ore cars equipped with Hyatt bearings are singularly free from the need of repairs, consequently they are ready for work day in and day out.



Power Saving

By a series of tests whose accuracy is vouched for by a number of the most prominent engineers associated with the mining industry, it has been proven that a reduction of at least 50% in draw bar pull (the force in pounds per ton required to move a car) can be expected from cars equipped with Hyatt bearings.

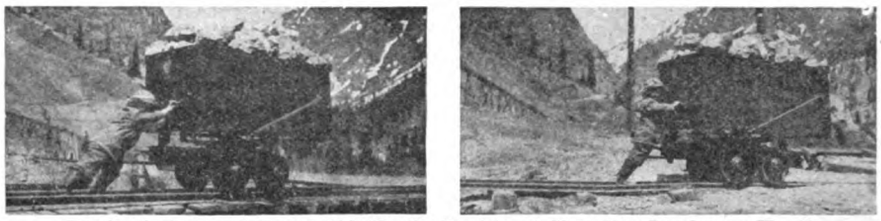
There is an even greater reduction in the starting effort as a plain bearing car requqires 2½ times as much effort to start from rest as does a Hyatt bearing car.

Maintenance Saving

Due to their design and their chrome-vanadium steel rollers, Hyatt bearings operate for years without appreciable wear and, therefore, without the necessity of adjustment or replacement. They also lessen the load on locomotives and thus eliminate storage battery strains and excessive wear on gears and pinions.

Who Uses Hyatt Bearing Ore Cars

There are thousands of Hyatt equipped ore cars giving dependable, economical, easy-running service in hundreds of the largest mines throughout this country and abroad. Many large companies such as Anaconda Copper and the Phelps-Dodge interests have standardized on Hyatt equipped ore cars and have replaced all old-fashioned plain bearing cars. In Phelps-Dodge's Copper Queen mine alone there are over 1900 Hyatt cars, the first of which were put in operation in 1909, and are still giving excellent service.



Benjamin Terry, 4 Years Old, Easily Pushing a Two-Ton Load on a Hyatt Bearing Equipped Ore Car.

These easy running cars are also greatly appreciated where hand tramming and mule haulage are used.

Lubrication Saving

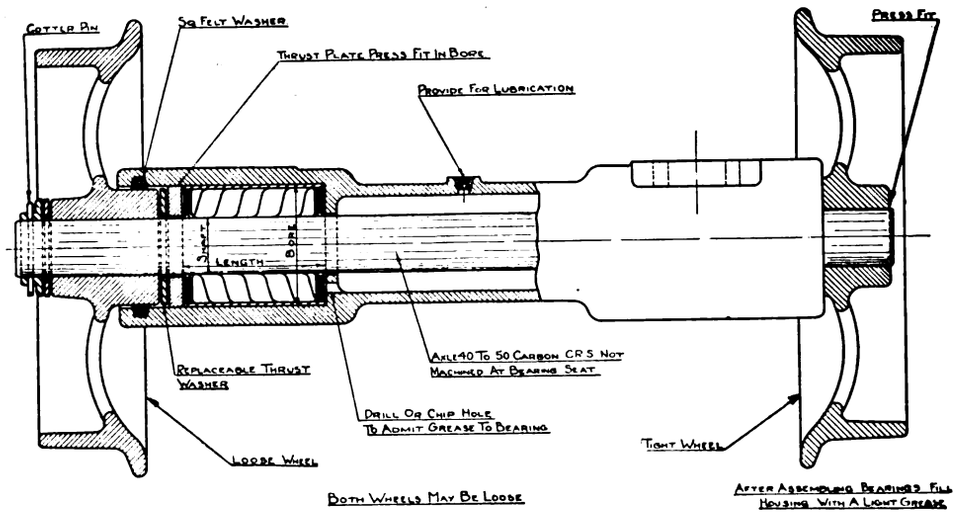
Users of Hyatt equipped ore cars report that their lubrication charges are reduced to from 50 to 80% of what they were when they used old fashioned plain bearing cars. This is due to the fact that Hyatt bearings only require lubrication three or four times a year.

The grease-tight housings hold a liberal supply of lubricant and the alternate right and left hand slots in the rollers distribute the lubricant constantly over all bearing surfaces.

How to Get Hyatt Bearing Ore Cars

The majority of the leading manufacturers of ore cars have been furnishing Hyatt bearing cars for many years and are prepared to give you the best type of equipment. Their designs have been worked out with the co-operation of Hyatt engineers and embody the most practical ideas in mine haulage equipment.

Competent Hyatt engineers will work with you and your ore car manufacturer in the selection of the best type of Hyatt bearing car to meet your needs, without obligation.



Typical Hyatt Bearing Ore Car Design With Continuous One Piece Axle Housing.

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Stafford Roller Bearing Car Truck Corporation

Plant and Executive Offices

LAWTON, MICH., U. S. A.

Stafford Frictionless Roller Bearings for Mining Car Trucks

Lighten Loads and Reduce Haulage Costs

The Stafford is the only practical roller bearing capable of withstanding the rigors of railroad service, and it brings to the Mining Car the same operating efficiency that results from its application to standard railroad car trucks.

These bearings lighten the load by the reduction of journal friction more than 90 per cent. Thus it is possible to move cars with less power or to materially increase capacities without increasing present power facilities.

The bearings are readily applied to existing equipment without making any important changes, and once in place they will endure indefinitely, and, on mining cars, require lubrication but once in two or three years.

Stafford Roller Bearings are made in a most exacting manner from selected chrome steel, and the rollers are so arranged in the substantial steel cage as to give a constant support to the load carried. They are built for heavy duty, and the fact that these bearings have been in test service on the Michigan Central Railroad since October 15, 1920, without repairs or upkeep cost and have shown a perfect performance record, without the development of hot boxes or other journal difficulties, is conclusive proof of their practicability.

They prevent derailments from excessive end thrusts, reduce power costs 50 per cent, completely eliminate cold weather journal difficulties and end lubrication troubles.

Stafford Roller Bearings are manufactured for standard railroad car equipment, electric railway car journals, mining cars, automobiles and motor trucks, line shafts and general machinery.

Mail us an outline of your requirements for roller bearings and we will send detailed data, including blue prints, cost of installation and estimated savings. No obligation. Address all communications to our main office at Lawton, Mich.

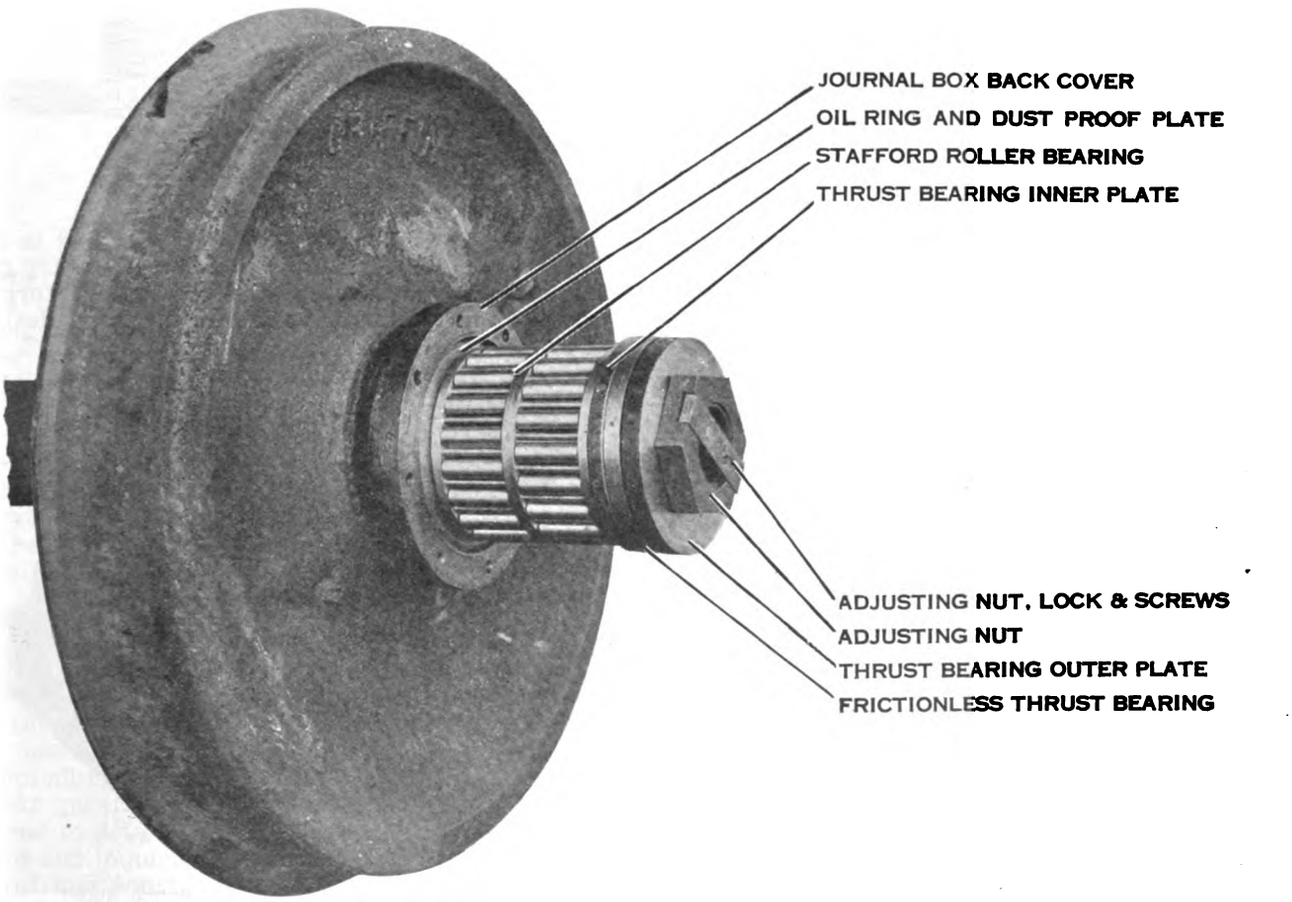

Illustration Shows Method of Applying Stafford Roller Bearings to Car Wheel Journals

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THE AMERICAN FROG & SWITCH CO.

Main Office and Works
HAMILTON, OHIO

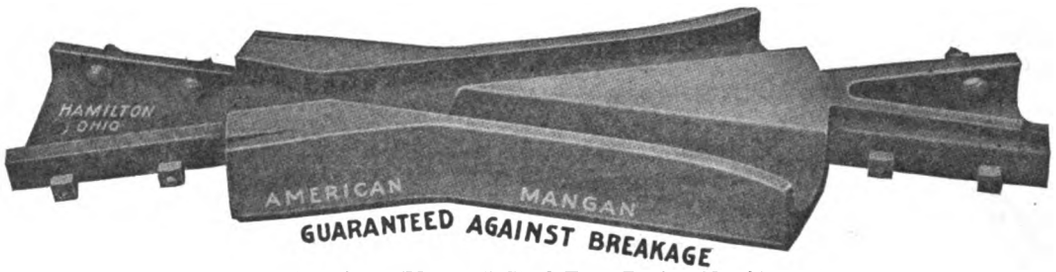
Railway Track Equipment

Products

A complete line of Track Equipment for Steam Railways, Mine and Industrial Service, fabricated from every section and weight of rail. Our manufacture includes all types of Railroad Frogs, Switches, Crossings, Switch Stands, Rail Braces and Tie Plates together with Special Layouts and Main Line Turnouts.

American "MANGAN" Steel Frog

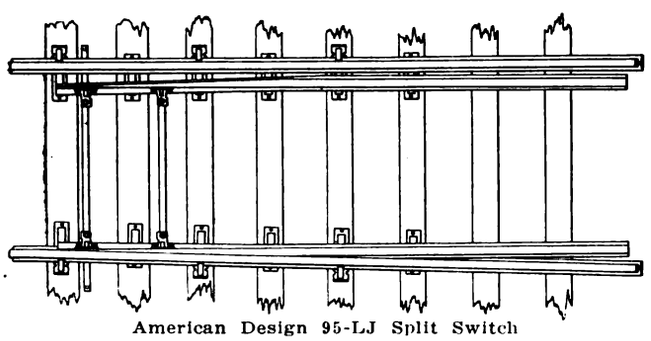
The "MANGAN" is the original "AMERICAN" design and is cast from our special alloy steel. The "MANGAN" is guaranteed against breakage and to give longer service than any other steel or rail frog offered on the market today. Though designed especially for mining purposes, the "MANGAN" is cast for any angle and to be used with any weight of rail and is furnished complete with all necessary bolts. The "MANGAN" is the cheapest frog to buy and will give five times the service of any other frog.



American "Mangan" Steel Frog Design No. 91

AMERICAN Design 95-LJ Split Switch

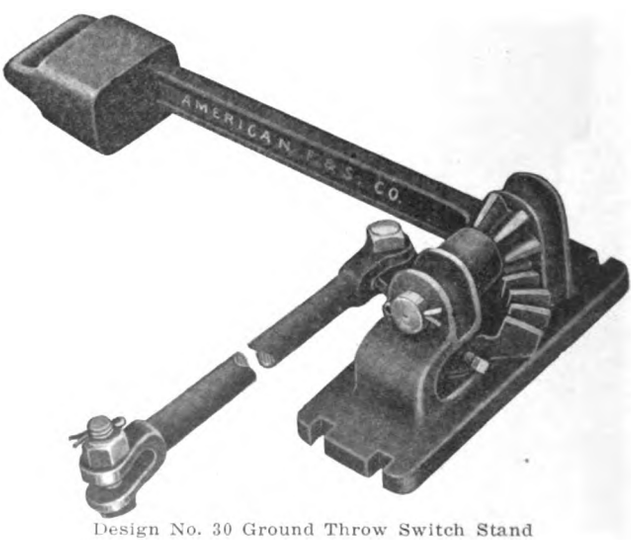
This Split Switch is designed for rail weighing fifty pounds and upward and for heavy duty in the mines and quarries. It is furnished complete with die formed steel lugs, rail braces, friction or slide plates. This length is equipped with two switch bars. We furnish all types of split switches.



American Design 95-LJ Split Switch

Ground Throw Switch Stands

In the opposite column we illustrate our Design 30 Switch Stand, throwing parallel with the track. It is the approved safety type. The stand is also made to operate automatically. Note the easy grip handles. All connecting rods are of solid forging bars without welds. We manufacture all designs of switch stands.



Design No. 30 Ground Throw Switch Stand

Let Us Quote On Your Requirements

Write For Our Catalogues

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THE C. S. CARD IRON WORKS CO.

DENVER, COLORADO

Manufacturers of

Mine Cars, Trucks, Rope Haulage and Track Equipment

Products

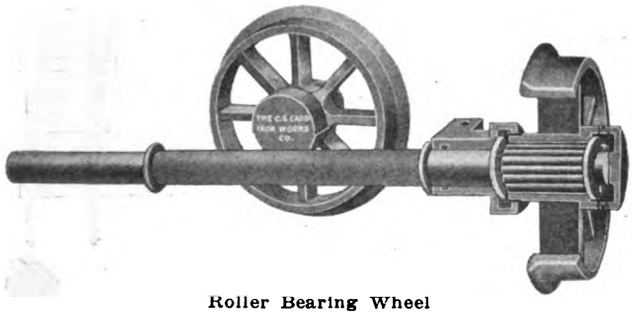
Mine Cars, Industrial Cars	Track Accessories	Cages
Trucks, Plain & Roller Bearing	Sheaves and Rollers (Track)	Skips
Car Couplings (Hitchings)	Chutes, Hoppers and Bin Gates	Revolving Screens
Wheels, Plain & Roller Bearing	Shaking Feeders	Bar or Grizzly Screens
Frogs and Switches	Cars, All Purposes	Dumps, All Kinds
Switch Stands	Rope Sheaves	Rail Benders
Crossings and Crossovers	Bicycle Spoke Sheaves	Gravity Plane Sheaves & Drums
Grease Guns	Rescreening Plants	Weigh Hoppers and Baskets

Mine and Industrial Cars

We are prepared to furnish cars for mines, mills, quarries, smelters, etc., made either to your specifications or we will design a car to suit your requirements. Estimates cheerfully furnished.

Wheels and Trucks

The illustration shows a roller bearing grease packed wheel with round axles and packed pedestals, which will run from three months to a year



Roller Bearing Wheel

on one lubrication depending on conditions. We make trucks with both plain and roller bearing wheels in combination with both round and square axles.

All wheels and castings are made in our own foundry where we can control the quality. Our specialty is chilled castings, particularly wheels which we make in both plate and spoke patterns.

By the time this catalog is off the press our Patented Combination Truck and Spring Drawbar will be on the market. Ask for descriptive literature.

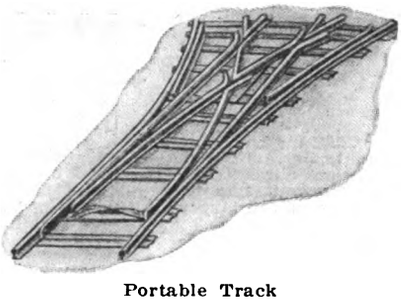
General

We have been manufacturing haulage equipment for the past thirty years. We operate our own foundry, forge and sheet metal shops, machine shop and wood working shop which allows us to control all the operations in our output.

Our general catalogue showing and describing our line in detail will be mailed on request. Your orders and inquiries are solicited and will be given prompt and courteous attention.

Track Equipment

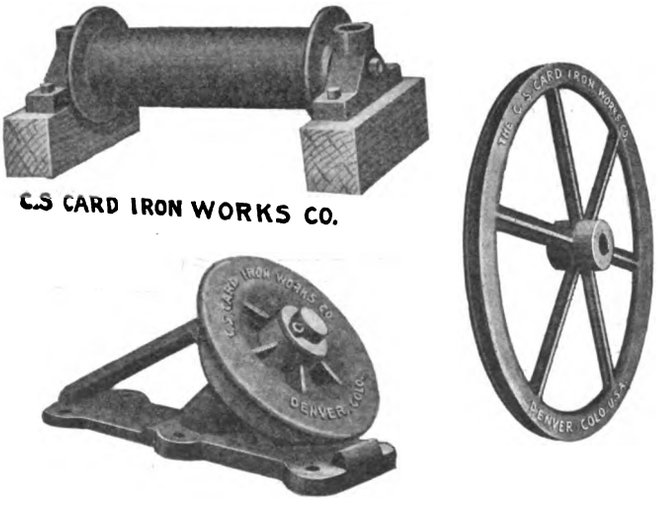
We make a complete line of rail work consisting of frogs, switches, crossings, crossovers, switch stands, etc., for mines, mills, smelters and industrial plants.



Portable Track

Rope Haulage Equipment

We make and carry in stock rope sheaves, curve sheaves, bicycle spoke sheaves, bull wheels, slope and knuckle rollers made with both grey iron and chilled faces. It is the most complete line in the west.



Rope Sheaves

The photographs illustrate but three of the styles we make.

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THE CENTRAL FROG & SWITCH CO.

GEORGE ASHTON, President

CINCINNATI, OHIO

E. R. HEITZMAN, Secretary & Treasurer

—Manufacturers—

Frogs, Switches, Crossings, Crossovers, Switch Stands, Turnouts, and Special Track Work for Mines, Mills and Railroads

---

Products

We manufacture a general line of track equipment such as Frogs, Switches, Crossovers, Crossings, Guard Rails, Guard Rail Clamps, Tipple Tracks, Incline Layouts, Room Turnouts, Tie Plates, Steel Ties, Portable and Industrial Track of every description.

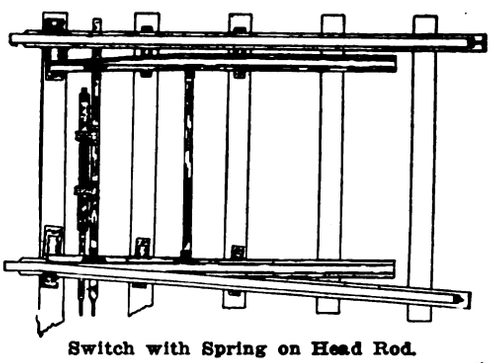
Specialty

We make a specialty of light rail Track Equipment for MINES.

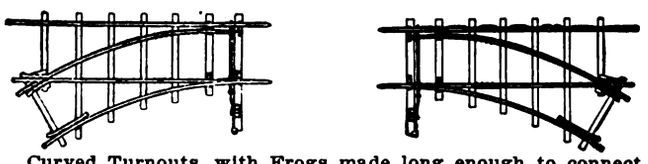
And maintain an expert engineering staff who will make a study of your special requirements.

Let us solve your transportation problems.

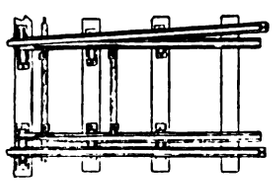
We will design your Layouts and make no charge for consulting engineering.

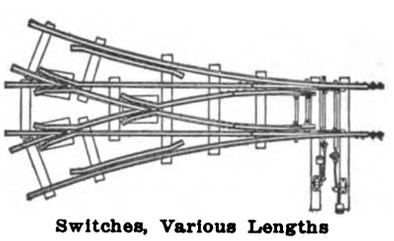


Switch with Spring on Head Rod.

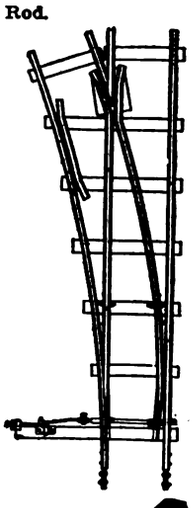


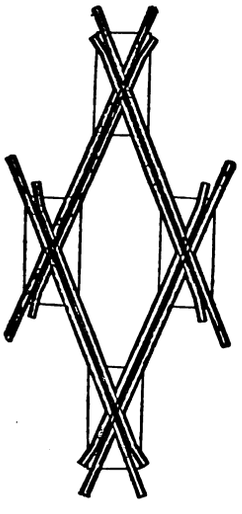
Curved Turnouts, with Frogs made long enough to connect direct to switch, thus eliminating short lead or filling rails. This type of Turnout has been adopted as the standard Turnout in a number of the largest mines in the United States.

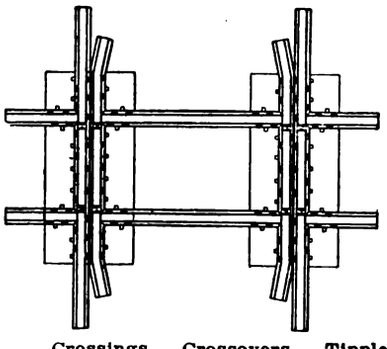




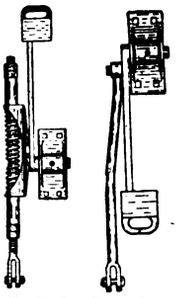
Switches, Various Lengths



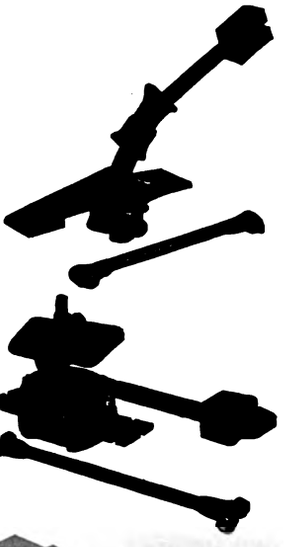


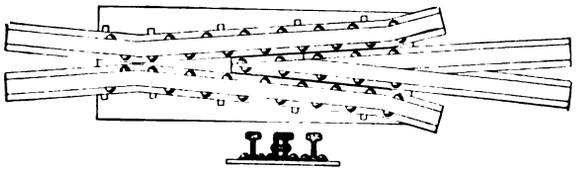


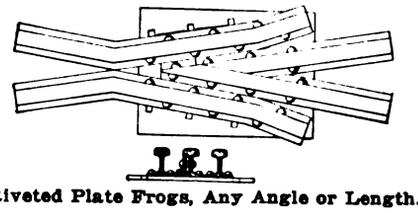
Crossings, Crossovers, Tipple Track and Incline Layouts to meet any and all conditions.



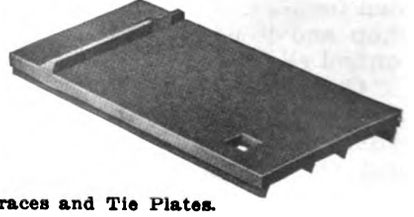
Switch Stands, Various Types.







Riveted Plate Frogs, Any Angle or Length.



Rail Braces and Tie Plates.

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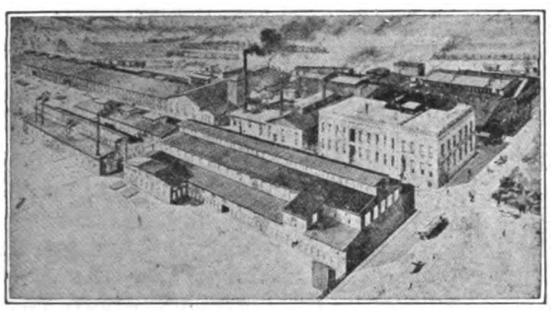
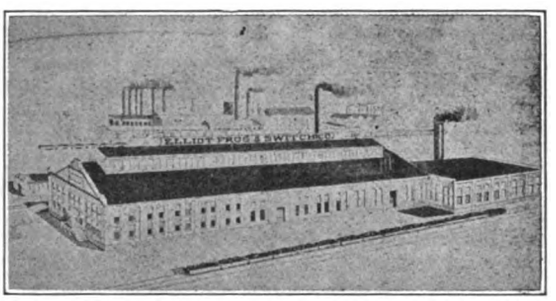
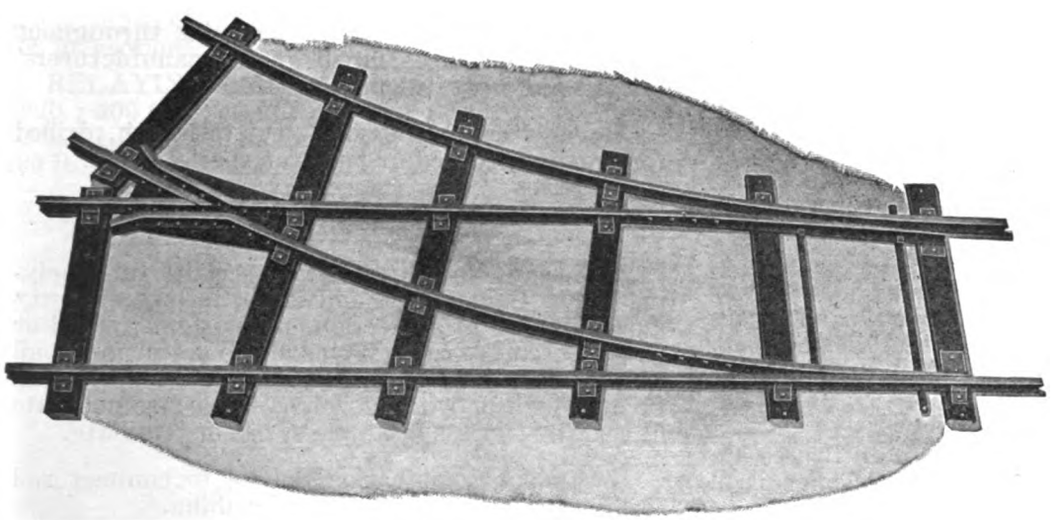


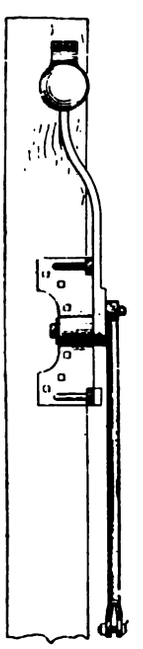
East St. Louis (Illinois) Plant



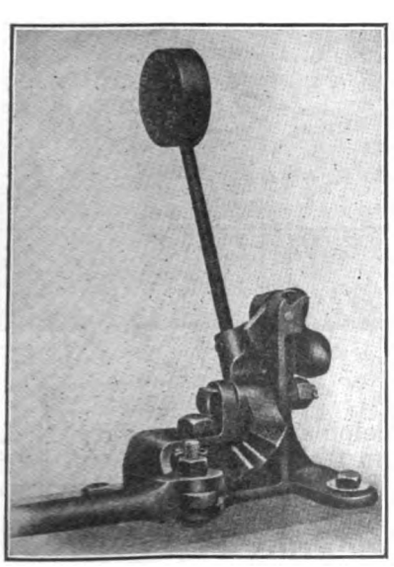
Pueblo (Colorado) Plant



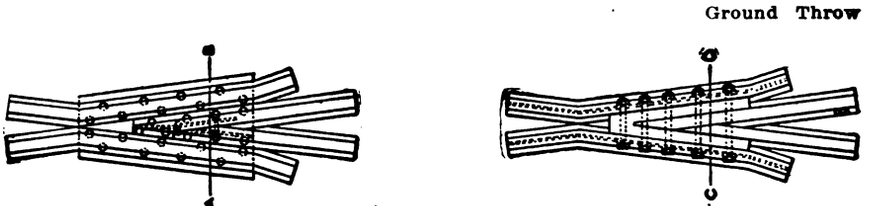
Portable Turnout



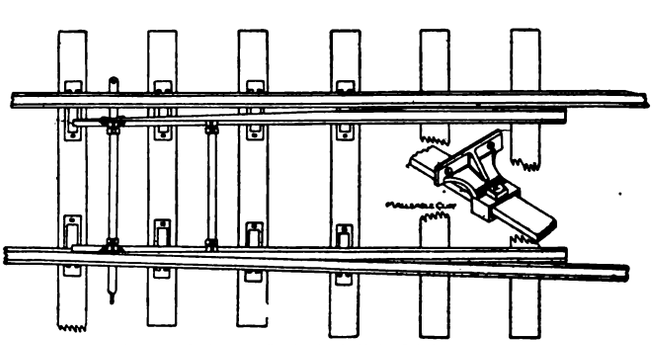
Ground Throw



Mine Stand



Mine Frogs



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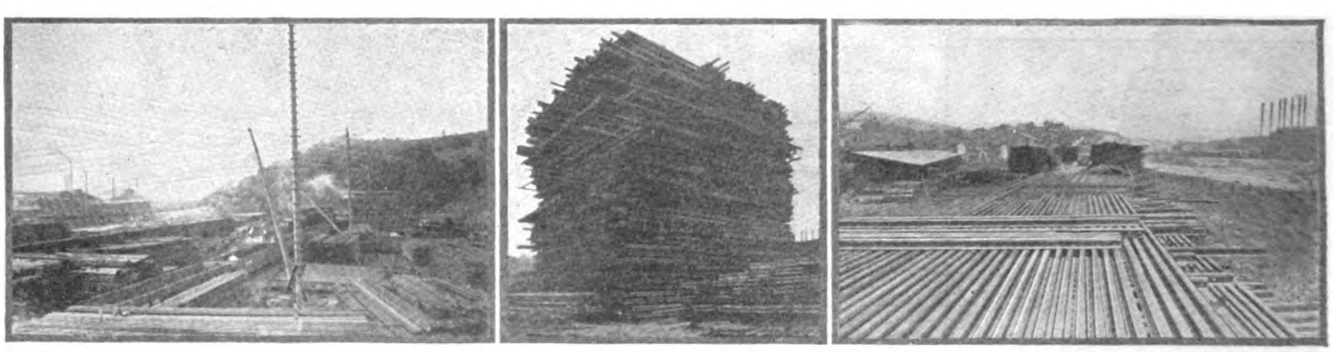

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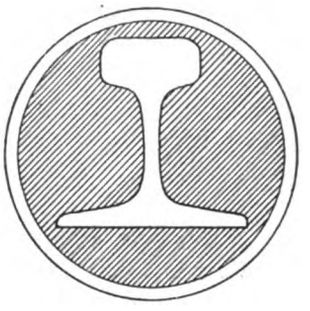

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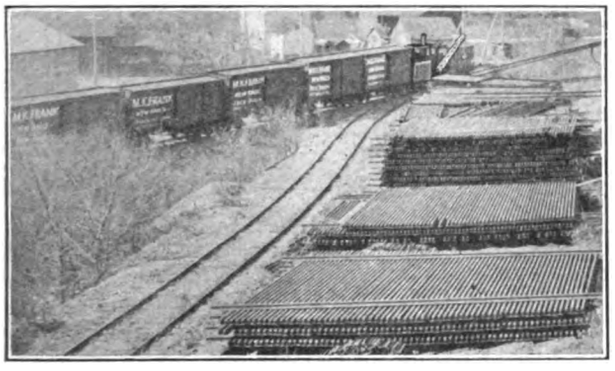

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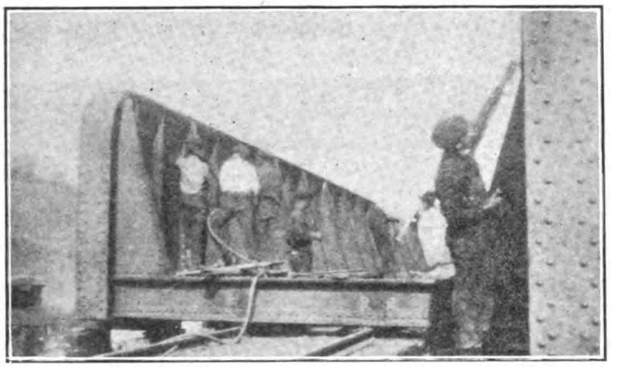

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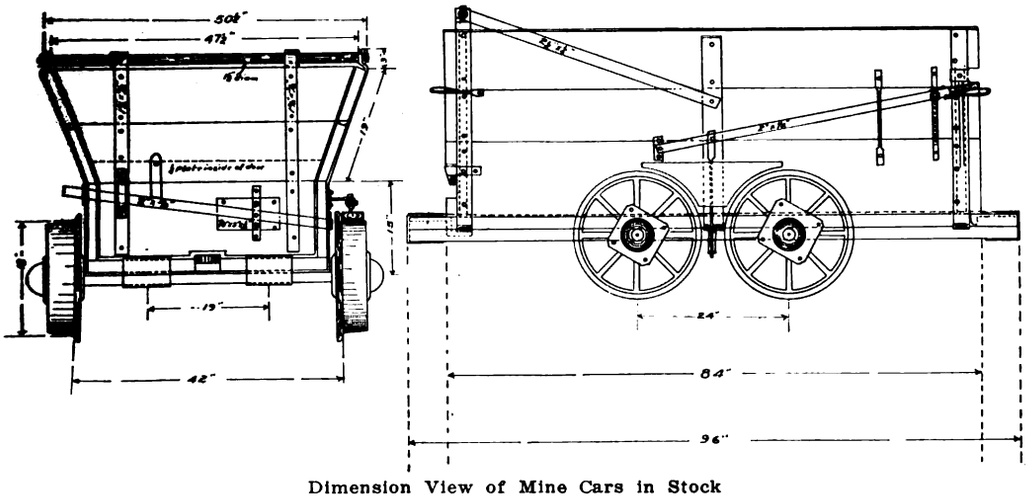

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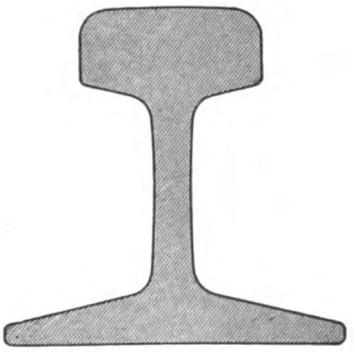

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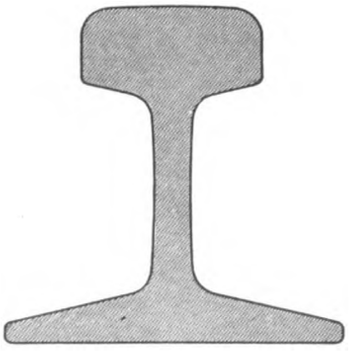

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SECTION VIII

Hoisting

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FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

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Lake Shore Engine Works
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Mundy, J. S. Hoisting Engine Co.
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Roebling's, John A. Sons Co.
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SEE PRODUCTS INDEX (Blue Sheets)

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SAFETY PRACTICE FOR HOISTING ROPE*

The Mining Section of The National Safety Council recently sent out a questionnaire to operators regarding the class of rope used, specifications required or obtained, factors of safety observed, methods of fastening ropes, lubrication, inspection, and points observed when rope is to be discarded. The answers received from this questionnaire, largely from metal mines, gives interesting information, from which recommendations for safety practice on hoisting ropes are drawn.

Depth of Mine

The depth in the majority of cases noted is from 1,000 ft. to 1,500 ft. (304 to 457 m.) and records come from a number hoisting from depths of 2,000 to 3,000 ft. Hoisting is generally done in balance, with a few companies using counterweights.

Seldom more than two shifts are occupied in hoisting. A number of large operators limit the shift for engineers to 6 hrs. A few of the larger operators have separate hoists for men and supplies, with a higher class rope for men. The range of loads varies from 7 to 17 tons and greater in a few cases, with a balanced weight of 4 to 7 tons.

Size of Drums and Sheaves

The size of drums and size of sheaves are generally in accordance with recommendations of rope manufacturers. Only one-half of the operators use grooved drums; one, The Sulphide Corporation, New South Wales, uses wood-lagged drums. Very few operators have drums capable of holding all the rope in a single wrap. Cone drums or cone and cylinder drums, in the mines heard from, are very rare.

A few mines of shallow depth use a small drum and large-sized sheave. While this may be allowed, and in some cases is all right, the size of drum and sheave should be fully equal to that recommended by the rope manufacturers and should be at least 60 to 100 times the diameter of the rope used, or one thousand times the diameter of the largest wire in any of the strands.

Operations show two wraps wherever possible, and not more than three wraps on the drum; the choice of several would be not more than one wrap if possible, and not more than two as good practice. A few operators, though too few, give importance to the distance at which the engine is set from the shaft and the fleet angle between sheave and drum. This, in most cases, can readily be arranged to reduce the fleet angle to 1° 30′, and provide at the same time a drum that will hold all the rope in one wrap or in not over two wraps. Hans Behr recommends, in specifications for hoisting engines, that the last groove shall rise gradually above the other grooves in order to start the second layer without shock. If, beside, grooved drums are used, these points will reduce the abrasion on the rope to a minimum.

The matter of overwind and underwind of ropes receives perhaps too little attention. The experience of operators in South Africa, according to Vaughan, of the Mines Department, indicates that the rope which underwinds wears more rapidly than the overwind rope by 20 per cent., and that the average life of rope is prolonged by alternating the ropes on the drums.

In a majority of cases, sheaves are cast iron, turned out true, 1/16 or ⅛ in. larger than the size of rope used. Others use special lining of cast iron, which is removable; the best type of this is the Nordberg sheave. Several companies use hardwood blocks, preferably maple. A few use hemp packing at first or to fill the groove when the sheave becomes worn.

More attention should be given to the material and weight of sheaves. These should be made as light as possible; the bicycle type preferred, larger diameter generally than recommended by rope manufacturers; set very firm in bearings, well babbitted; aligned carefully with center of drum, observing the lead or fleet angle mentioned previously. Wooden linings have generally proved satisfactory where used, though such linings add greatly to the weight and require much care in renewal. The best wood lining is maple soaked in linseed oil. Cast-iron sheaves or cast-iron liners prove most satisfactory. Grooves must be kept true and machined to the same diameter of drums and to the proper width of groove when new rope is put on. Top of head frames and sheaves should be more easily accessible for frequent inspection.

Size of Rope

Ropes vary in size from 1 to 1½ in., generally 6 x 19, hemp center. A majority of the operators use the higher class rope, plow steel or special brands, improved, and a few use a flattened strand, 6 x 25. A good number prefer the Lang lay, which is the favorite with larger operators hoisting from the greater depths. Lang lay ropes are used in nine cases out of ten in South Africa; they are in very general use in Australia, and their use is becoming more general in this country. The Sulphide Corporation uses 6 x 7 Lang lay rope, improved plow-steel wires, and finds that both longer service and more satisfactory inspection for wear and corrosion can be obtained. The experience of the New Jersey Zinc Company is much the same; particularly in its Incline shaft, it finds the plow-steel wire the best for its conditions. Care is required, in using the Lang lay rope, in the early operations, to see that no bird-caging or kinks develop. Such a thing is possible when chairs are in use; in which case care must be taken that no more rope is unwound from the drum than is required to reach the chairs. A solid attachment for Lang lay should always be made, not a swivel attachment. Possible twists should be taken out, with much care, once or twice when new rope is put into service.

*Paper read at The American Institute of Mining and Metallurgical Engineers, New York meeting, February, 1922, by R. M. Raymond, Professor of Mining Engineering, Columbia University, New York, N. Y.

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Rope Specifications

Few companies stipulate specifications for rope; reliance is placed on the tensile strength given by the manufacturers. Preference is shown for plow steel by the larger operators, with the understanding that the tensile strength of the wire is, or approaches, 200,000 lb. per sq. in. The International Nickel Company calls for tenders from manufacturers, gives full description of working conditions, and asks manufacturers to recommend rope for these conditions, with complete description. It requires a factor of safety of seven for hoisting ore and a factor of safety of ten for the main hoist. The United Verde mine stipulates low-phosphorus steel, high carbon and manganese, with a tensile strength of the wires of 200,000 lb. per sq. in. The Copper Range Company stipulates 1¼-in. plow steel, 6 x 19, regular lay; 58 tons tensile strength, and on test has found the rope to have a strength of 75 tons. The Broken Hill mine uses 1¼-in. 6 x 19, Lang lay, and specifies a breaking stress of the rope of 60 tons and best flexible plow steel or its equivalent. The Anaconda Company does not specify particularly, but uses improved plow-steel in all cases.

While the manufacturers' recommendations seem to be generally satisfactory, it is most important that purchasers give clearly their working conditions, nature of shaft lining, attention given to timbers and guides, the factor of safety desired, whether mine water is acid or not, and whether harmful gases are encountered in the lower part or any portion of the mine.

A more satisfactory statement from the manufacturers would be the tensile strength of steel from which the wire is drawn, as well as the breaking strength of the rope; the aggregate strength of all the wires is 10 to 20 per cent. less than that of the wire bar. When new rope is purchased, a certificate should be required from the manufacturer, the rope should be stored under cover, in a cool place, properly coiled and not left on the ground.

The Canadian mining law requires a certificate from the manufacturer showing date of manufacture, size, weight, number and size of wires, class of core, breaking stress of steel from which wire is made, and estimated breaking load of rope. This certificate is recorded in the "Rope Record Book" and additional data kept of operation of rope when in use at the mine.

Factor of Safety of Ropes

The factor of safety stipulated or estimated varies considerably, generally that estimated by the manufacturers in supplying rope is considered satisfactory, and is five to six for new rope. Factors of safety for worn rope vary from three and one-half to five, and these variations for discarding rope correspond somewhat with speed and depth.

None of the State laws in this country indicate any factor of safety. The Canadian mining law stipulates a factor of safety of six in shafts less than 2,000 ft. deep; and in shafts 2,000 to 3,000 ft., not less than five. The International Nickel Company uses a factor of seven and specifies such a rope for its conditions. The Commission appointed in South Africa to inquire into the use of hoisting ropes considered this matter carefully and recommended a minimum factor of safety of six, but believes that for deep levels it is impossible to start with a factor of safety of more than seven. Such a rope, when reduced to a factor of safety of six, may be used for six months longer but no more, and even then will have an enormous reserve of strength. It was proved also that shocks due to changes in velocity were dangerous only to short lengths; in lengths of 1,500 ft. and over shocks would remain constant. The New South Wales mining law requires that a rope be tested before use and that it have a factor of safety of eight for ore and of ten for men. The Sulphide Corporation uses a factor of safety of nine for new rope on ore and of ten for rope on man hoists. The regulations of the new mining law proposed for this country are as follows:

"The factor of safety of ropes when newly installed in shafts less than 3,000 ft. deep shall in no case be less than six.

"It shall be unlawful to use any rope or cable for the raising or lowering of men when its factor of safety, based on its existing strength and dead load, shall have fallen below 4.5.

"It shall be unlawful to use any rope or cable of the so-called 6 x 19 standard construction for the raising or lowering of men, either when the number of broken wires in one lay of said rope exceeds six, or when the wires on the crown of the strands are worn down to less than 65 per cent. of their original diameter, or when the superficial inspection provided for in this section shows marked signs of corrosion: Provided, however, that when such broken wires are reduced by wear more than 30 per cent. in cross section, the number of breaks in any lay of the rope shall not exceed three."

The committee framing the law discussed the matter of safety with manufacturers and a variable safety factor was recommended, dependent on the depth of shafts. This is given in Table 1.

TABLE 1. FACTORS OF SAFETY RECOMMENDED FOR HOISTING ROPES.

Length of Rope, in Feet	Minimum Safety Factor for New Rope	Minimum Safety When Rope Must Be Discarded	Percentage Reduction
500 or less.....	8	6.4	20.0
500 to 1000.....	7	5.8	17.0
1000 to 2000.....	6	5.0	16.5
2000 to 3000.....	5	4.3	14.0
3000 and over.....	4	3.6	10.0

It would seem that the variable factor of safety suggested for the new mining law is a good recommendation, but a maximum factor of safety of not less than six, and a minimum of not less than four and one-half would be better for depths below 2,000 ft. Where man hoists and ore hoists are in use in the same shaft and the same size of rope used, it would be well to change the ropes from the man hoists to the ore hoists after a period of six months or a year.

Hoisting Speed

Speed in the shallow shafts submitted is from 600 to 1,000 ft. per min. for ore, and in deeper shafts 1,600 to 3,000 ft. per min. Speed for hoisting men in almost all cases is reduced to 400 to 600

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ft., though in a few cases it runs as high as 1,000 ft. per min. Acceleration varies considerably, depending on depth. Table 2 shows acceleration practiced by several of the important operators.

TABLE 2. ACCELERATION IN VARIOUS MINES.

	Shaft	Average Length of Haul, Feet	Maximum Hoisting Speed, Feet per Min.	Acceleration, Ft. per Sec.	Length to Reach Max. Speed, Feet	Time to Reach Max. Speed, Seconds
N. J. Zinc Co., Franklin, N. J...	Inclined	915	3000	3.33	375	15
Inter. Nickel Co., Creighton, Ont...	Inclined	1600	1100	2.33	260	15
Witherbee-Sherman, Mineville, N. Y..	Inclined	1000	1200	1.33	150	15
Copper Range Co., Painsdale, Mich..	Inclined	1500	2360	2.48	130	10
Republic Iron & Steel Co., Birmingham, Ala.....	Inclined	5400	2200	1.47	459	25
Sulphide Corp., N. S. W., Australia.....	Vertical	825	3650	5.06	300	15
Calumet & Arizona, Warren, Ariz.....	Vertical	1500	1600	5.33	70	5
United Verde Copper Co., Clarkdale, Ariz.	Vertical	850	2000	4.7	115	10
North Butte Co., Butte, Mont.....	Vertical	3600	2700	2.53	400	17
Great Boulder Prop. Boulder, W. A...	Vertical	2000	2000	5.85	95	6
Old Ben Corp., Frankfort, Ill....	Vertical	475	3600	12.00	150	5

Compared with the draft of the new mining law, the speeds for hoisting and accelerating practiced by the different companies do not show any excess over the speeds recommended. In fact, the acceleration speeds practiced are considerably lower than the maximum allowed acceleration of the proposed law. An accelerating speed of 3 to 4 ft. per sec. for depths of 2,000 ft. is preferable to the maximum acceleration suggested. Speed for hoisting men varies considerably and practice varies in different countries. Speed on such occasions should not be over 500 to 600 ft. per min. For great depths, higher speed may be permitted, with the period of acceleration and of retardation extended. The Mines Inspection Act of New South Wales requires a cage speed no greater than 300 ft. per min. within 50 ft. of the surface or bottom, when hoisting men. Great care should be taken in starting and stopping, especially with new rope. It is most important that no slack be permitted when the hoist is resting on chairs; with a foot of slack in the rope's length, a jerk may cause a stress of four times the weight lifted.

Inspection of Ropes

Method and frequency of inspection of ropes vary from daily inspection of terminals, including wraps remaining on drums, to weekly inspection. Fully 70 per cent. of the operators make inspection daily, and one makes inspection three times a day when hoisting men. Daily inspection is in some cases left to hoistmen, who in a few cases are depended on to watch and report broken wires. Daily inspection, generally, is made by the mine foreman, and minute inspection made weekly, twice per month or monthly, by the foreman and assistant to master mechanic, or other competent persons. In a few cases the entire length of rope is inspected carefully once a week, running the rope through the inspector's hands. One company inspects new ropes every two weeks with a magnifying glass. When rope shows signs of wear, inspections are made more frequently. Terminals are cut off every two or three months, in lengths of 3 to 10 ft.

Generally speaking, rope inspection is quite thorough; and from the experience of the greater number of the operators giving replies, a standard conclusion may be made as follows:

Daily inspection of terminals should be made, including wraps remaining on the drum when the cage or skip is down; daily inspection of both the terminals above cage or skip, and of the rope at point of contact with sheaves. On new ropes the latter spot is important; and while it varies slightly due to the stretch, a short cut every month for the first three months is a point worth considering. Thorough inspection of the whole length of rope should be made every week, and twice a week when the rope is new. Once a month portions of the rope should be carefully inspected in sections that are likely to show wear and the rope should be cleaned for this purpose. Examination of rope fastenings should be made before hoisting men. The Mining Act of Canada stipulates that rope shall be examined once a month to ascertain deterioration. For this purpose the rope must be thoroughly cleaned at points selected by inspectors, who shall note reduction in circumference and the proportion of wear. Results of inspection should be made in Rope Record Book and a copy of weekly and monthly inspections sent to mine superintendent and mine manager.

Fastening of Rope to Drum and to Cage

Fastening on drums in all cases is made by three wraps, at least, remaining on drum when the cage is at the bottom. The rope is then passed through a hole in the drum at a very acute angle, with one or two turns around the shaft, and fastened back on itself with two clamps or clips, or fastened around a spoke with clamps; or better,

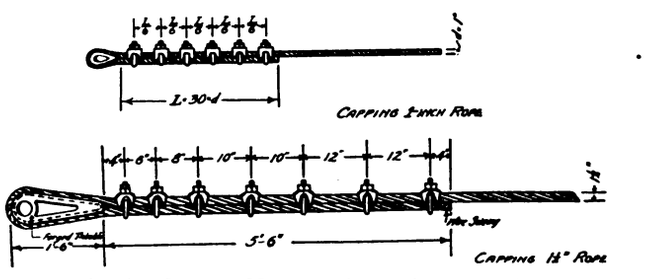

Fig. 1. Correct Method of Capping Wire Rope.

fastened by a clamp cast in the spindle of the drum. At least two full wraps, and better three, should remain on the drum when the cage is at the bottom of the shaft. The terminal inside the drum should be fastened securely and inspected frequently.

Fastening at the cage or skip, in most cases, is done by means of clips or clamps. Reports show

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that these are placed at varying intervals, the U-bolt of the clamp usually being placed on the loose end of the rope and the cast portion of the clamp on the solid portion of the rope. The portion of the rope covered by the clamps, or a length of 6 ft. to 10 ft. or 20 ft. is cut off every three or every six months, or whenever inspection shows that it is necessary. In a few cases, half the clamps are renewed every six months.

Fastening to the cage by clamps seems to give the best opportunity for inspection, and while sockets are considered and reported generally as satisfactory, the majority of operators prefer the clamps. These should be fastened as shown in Fig. 1, the rope being passed around a large thimble, and further secured by means of locknuts. Careful inspection should be made of the rope when clips are attached to see that it is free from any broken wires and that the rope is thoroughly clean when the clips are attached. Nuts and locknuts should be examined every day on the regular inspection of the ropes. Lengths of at

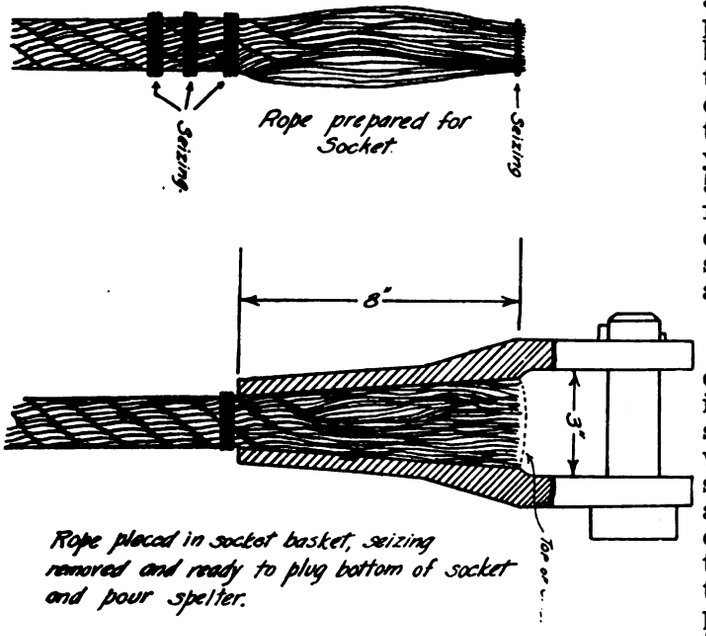

Fig. 2. Correct Method of Socketing Wire Rope, Great Boulder Proprietary Gold Mines.

least 10 to 20 ft. should be cut off every three months or six months, depending on hoisting conditions and the amount of ore hoisted. Strains will show on the portion of the rope attached to the thimble and the portion of the rope in advance of the clips. When rope is cut off, the portion above the clips should be periodically tested to find the tensile strength of the rope at the point; the size and diameter should be noted, also the condition of the wire, and this diameter compared with the original diameter of the rope. Also, an examination of the interior of the rope and the condition of the hemp core should be made, as well as an examination for corrosion and brittleness of the wires, which is likely to be most severe in the lengths near the cage. The International Nickel Company regularly sends a specimen of the rope cut off to a testing laboratory.

While two-thirds of the operators use clips, a number use sockets, and very careful attention is given to the socketing of the ropes. In most cases in which they are used, when the wires are properly secured, sockets are found quite satisfactory. The Sulphide Corporation of New South Wales found that sockets did not give sufficient opportunity for inspection and that corrosion occurred although at other points the rope showed no indication of such a thing. The Hudson Coal Company and the Great Boulder mine use a socket longer than that generally used (see Fig. 2). This permits the rope to extend into the socket a short distance in unaltered form, about 2 in. in the case of the Great Boulder mine and 5 in. in the practice of the Hudson Coal Company. This gives greater strength at the point of contact of rope and socket and less breaking action on the individual wires. The method of these companies is to separate the wires, cut out the core to the point where the rope remains intact, clean the wires with gasoline and diluted muriatic acid, wash them in a dilute solution of soda, insert them in the socket to the upper seizings on the rope, taking care to get them in an absolutely straight line. The Hudson Coal Company and most of the operators simply loosen and broom out the wires. The Great Boulder finds that turning the wires nearly at right angles does not cause the wires to break, and has found this practice satisfactory in severe work for over twenty years. The socket is warmed to a temperature of 50° to 60° F. and pure spelter is poured in carefully and continuously until it fills the socket and covers the wires. Ropes newly capped, either by socket or by clips, should be run several trips with a light load before heavy loads or men are handled.

Where sockets are used for fastening, the greatest care should be taken in cleaning the wires and in setting them before the metal is poured into the socket, so that uniform stress will come on each wire. Sockets should be cut out every three or six months. Lengths of rope 6 to 10 ft. should also be cut off every three months or six months, depending on hoisting conditions, load, stress on the rope, as well as water and atmospheric conditions. Careful examination and tests of these pieces should be made, as mentioned under inspection of clips.

Life of Rope

On this point considerable diversity of practice prevails. Several operators discard rope when the wires on the outside of the strands are worn to less than 60 per cent. of the original area, and when inspection shows signs of corrosion. Others take more particular note of the number of broken wires. One company discards rope when the number of broken wires in any consecutive 10 ft. exceeds 10 per cent. of the total wires in the rope; another very careful company condemns the rope when twelve wires per foot are found, or if the wires be pitted and can be pried out of place easily, even if no broken wires are found; another discards rope when 60 to 70 wires are broken in one strand. One company finds that a decrease of 1/8-in. (3.17 mm.) in diameter renders the rope unserviceable and cuts grooves in the sheaves; another com-

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pany abandons the rope when a decrease of 3/16 in. in diameter is shown or when seven wires are broken in any one strand. The Anaconda Copper Company discards when not more than 20 per cent. of the strength of the rope is used up by abrasion and broken wires. The Sulphide Corporation generally discards its 6 x 7 rope when one wire in any lay shows fractures; even if apparently in good condition, rope is discarded after two years' service. A few companies put a time limit on the use of the rope, even when characteristics of the rope are good. One iron company turns the rope end for end every six months and discards it after a use of twelve months. The International Nickel Company, which takes special care of its ropes, abandons them after two years use, even if the rope is apparently in good condition.

After the tensile strength of ropes of regular lay has been reduced 25 per cent. by alteration and wear, the limit of safety has usually been reached. With Lang lay rope this reduction may be extended to 30 or 35 per cent. of the tensile strength. When wires of the ordinary lay on the outer side of any strand are worn to 60 per cent. of the original area, or when outer wires of the Lang lay are reduced to 50 per cent. of their original area, it is safe practice to abandon the rope. The number of broken wires permissible in any one lay should be very few. Some companies discard the rope when the number of breaks in any consecutive 10 ft. exceeds 10 per cent. of the total number of wires composing the rope, which seems as many as should be allowed. The proposed mining law concludes that if six broken wires occur in any lay, the rope should be condemned. With these differences in point of view and of practice, must be considered the reduction of safety factor ascertained by tests, the corrosion, if any, effect of the mine atmosphere, the work done by the rope, speed of hoisting, etc. Good practice to follow which will assist in the life of the rope would be to change ropes from one drum to the other every six months, so that the rope having the underwind on the drum shall be alternated with the rope having the overwind. Ropes should be turned end for end every six months or every year, depending on the life that is found possible and permissible. Where a rope is in constant active service and in heavy duty, good attention to all details gives records of fully two years life, with a possibility of longer time. Light or irregular duty may permit use for longer time in service. The wearing parts, the working conditions, the broken wires due to wear must, with careful inspection, determine the safe period for use.

Lubrication of Rope

Lubrication of rope varies from the use of any of the compounds manufactured by the oil companies for hoisting rope, to a combination of these compounds with oil, in the colder countries, and, in some cases crude oil, or alternate applications of oil and rope compound combined. A few companies lubricate with heavy black oil or crude oil, arranged to drip on at the sheaves, with special dressing of compound at intervals. The greater number prefer the lubricating compounds made especially for ropes. One mine which encounters acid water applies thin compound, followed by heavier compound once a month. The International Nickel Company uses the same lubricant applied every two weeks. In winter this is followed by black oil; the rope is passed through a hollow box and the heated lubricant is poured in. A number of companies prefer a special compound of the Texas oils for wet shafts, applied every two weeks; another company uses a lubricant every 60 days, with an additional drip above the sheaves, using waste oil from the compressors.

The Great Boulder mine uses castor oil, applied through a tray or cone bolted around the rope, with a gland or valve at the lower part of the cone packed with rubber. As salt water is encountered in the shaft, the rope must be carefully lubricated, every three weeks. The use of oil in connection with lubrication, as practiced by several of the companies, is a wise method. Lubrication must not only be for the outer part of the rope but for the lubrication of the individual wires inside the strands. Heating the lubricant aids its power of penetration. In experiments made by The International Nickel Company, cold oil applied to a core did not penetrate to the hemp in the core at all, but a considerable amount of hot oil did reach the hemp.

Old lubricant on the rope should be cleaned off every three or six months by running the rope through steam in a trough and swabbing off the rope well. Hot oil should then be applied, and a good lubricant, free from acid, should be applied every two or three weeks. One of the main objects to keep in mind is to apply, first, heated oil which will penetrate to the inside of the strands and then the heavy outer lubricant, and both should be well rubbed in.

Rollers in Inclined Shafts

Practice is about evenly divided between the use of wooden and steel rollers. One large company operating with heavy loads in a shaft, with an inclination of 60°, uses lap-welded boiler tubing 12 in. long, 6 in. in diameter, with spindles turning on bronze bearings in cast steel frames. This gives entire satisfaction. The Great Boulder mine finds steel rollers 8 in. in diameter very satisfactory; also that disks of old belting 8 in. in diameter, clamped together, make very good rollers. The Ray mine, Arizona, Cranberry Creek coal mine, Witherbee-Sherman mine all use wooden rollers. The Copper Range Company uses rollers made up of wrought-iron disks 32 in. in diameter, filled with maple blocks wedged in on spindle which is set in bearings brass bushed. These work very satisfactorily. The Wharton Steel Company uses steel rollers on roller bearings, which have worked very well. General South African practice favors steel rollers, which are preferred to any other, and these, with care, have given good service.

Acknowledgments are herewith made to the friends and officials who replied to the Questionnaire; also to Mr. Hans Behr and to Mr. B. F. Tillson, for suggestions for good practice.

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HOISTING ROPES*

Five types of steel-wire ropes are used in hoisting—the ordinary lay, the Lang lay, the non-spinning, the lock coil, and the flat rope. The ordinary lay and Lang lay ropes are most used for hoisting. Non-spinning ropes are used for bucket hoisting. The lock-coil rope is used to a considerable extent in England but not in the United States. It is non-spinning and could be used for bucket hoisting. Flat ropes are used with reel hoists. The rope most used in American mining practice is the ordinary lay. Some Lang lay ropes are used as well as the flattened strand. Non-spinning ropes are not much used.

The ordinary lay rope consists usually of six strands twisted about a hemp center. The strands are composed of seven, twelve, fifteen, or nineteen wires. Flexibility is obtained by increasing the number of wires in an individual strand. Ropes with a greater number of wires to the strand than nineteen are not used in hoisting, as they wear rapidly. The standard for hoisting is six strands, nineteen wires to a strand. Maximum wear is obtained by using wires of large diameter, and this limits the number of wires to a strand. Ropes made of strands containing seven to twelve wires are less flexible, but wear longer, and are used for haulage.

Strands are constructed of circular or oval section. The "flattened strand" rope is made of strands of oval section. In still another type, the strands are of approximately triangular section and give a rope of the same characteristics as the flattened-strand rope. Such ropes present a greater number of wires on the crown of the strand and thus will withstand a greater amount of wear than the circular strand. In ropes of ordinary lay, the wires in the strand are twisted in one direction and the strands in the opposite when made into a rope. The rope is in more or less equilibrium, although it will untwist when loaded and requires a rope attachment which prevents turning. The length of lay or twist in the strand is one-third that of the lay of the rope. Ropes of ordinary lay cannot be used for bucket hoisting, as they cause the bucket to spin.

In ropes of Lang lay the twist of the wires in the strand and the strands in the rope are both in the same direction. The rope is not in equilibrium, and the attachment must be such as to prevent untwisting. Such ropes cannot be used for bucket hoisting. Lang lay ropes have proved in practice to give greater resistance to wear and greater freedom from weakening through bending. They give excellent service in haulage work.

Non-spinning ropes are used for sinking operations where bucket hoisting is necessary. They are made of two sets of strands, an inner set of ordinary strands which are twisted in one direction and an outer set twisted in the opposite direction. The rope is "dead"—that is, it will not untwist under load.

Lock-coil ropes are constructed of an inner core of round wires and three outer layers of wires of a special section which admits of locking the wires together. A smooth outer surface like that of a solid bar is presented. Such ropes are flexible enough for hoisting, are non-spinning, and wear excellently. They weigh more per unit of length and are stronger than round ropes of equivalent size. The lock-coil rope has a section of solid metal equivalent to 90 or more per cent. of the area of the circle inclosing the rope, the flattened strand about 70 per cent., and ropes of ordinary lay from 50 to 60 per cent.

Flat ropes consist of a series of strands of opposite lay laced together with soft iron wire. The lacing wears rapidly, and such ropes have to be replaced at quite frequent intervals. The maintenance cost and the necessity for rope-repairing equipment are the principal reasons for the restricted use of flat ropes. They are still used in some mining districts. They are also used for counter-balance ropes in the Koepe system of hoisting. Their greater weight for equal strength is another objection to exclusive adoption, the excess weight ranging from 12 to 20 per cent. more than that of round ropes. Catalogs give about 5 per cent. to 15 per cent.

The thickness of flat ropes is specified by the diameter of the strands used before sewing. The finished diameters of the ropes, however, are slightly in excess of this, due to the enlargement of other strands by the insertion of sewing wires.

In very deep shafts using long hoisting ropes, it is desirable to have ropes which are neutral, that is, have no tendency to twist and untwist, a condition fulfilled by flat ropes.

Where large as well as long ropes are necessary, on account of the heavy loads which have to be hoisted, round ropes necessitate the use of large, heavy and expensive winding drums, while flat ropes are wound upon themselves on reels of moderate diameter, simple in construction and only slightly in excess of the width of the ropes, and hence less expensive equipment is required. Where mines are located in places accessible only by pack-trains, this reduction in the bulk and weight of hoisting machinery is quite vital.

When two ropes are used together, one to hoist and the other to lower a cage at the same time, operated by the same engine, all of the advantages of large conical drums, without a great mass of moving machinery, are attained in employing flat ropes, together with an added economy of power.

The Anaconda Copper Mining Company has flat steel ropes in use on double reel hoists at the following mines in Butte, Mont.:

Anaconda Mine—½″ x 7½″ x 2900′.
St. Lawrence Mine—½″ x 7½″ x 2720′.
Belmont Mine—½″ x 7½″ x 2800′.
Emma Mine—½″ x 5″ x 1850′.
Bell Mine—7/16″ x 7″ x 3900′.
High Ore Mine—7/16″ x 7″ x 3700′.
West Colusa Mine—⅜″ x 6″ x 2300′.
West Gray Rock Mine—⅜″ x 6″ x 2040′.
Silver Bow Mine—⅜″ x 4½″ x 1200′.

*Engineering and Mining Journal, March 18, 1922. Roebling's Price List for November 1, 1919. Letter from Mr. Jaccard, Anaconda Mining Co.

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Flat ropes were in very general use in the Butte district at one time, but are being superceded by round ropes as new engines are installed. This is due to the fact that the ground around many of the shafts has a tendency to move, making it almost impossible to keep the flat ropes properly lined with the sheaves.

Advantages

Flat ropes possess certain advantages in that the hoist may be set close to the shaft. They do not twist in the shaft, and they are easily inspected. On the other hand, they must be changed and resewed at frequent intervals, and considerable equipment must be kept on hand to do this work.

The material used in the construction of wire ropes is iron, ordinary steel, crucible steel, plough steel, and steels of special quality. The wire used will range from a tensile strength of from 100 to 135 tons per sq. in. The grade most used has a tensile strength of 120 tons per sq. in. In some rope manufacture steel of a tensile strength of 150 tons is used. The wire is hard-drawn and is subjected to tensile, torsion, and bending tests. The number of flexures under standard conditions for new wire is from twelve to twenty. (The wire is clamped in jaws the edges of which are rounded with a radius off 5 mm. The wire is bent through an angle of 90° and back for each flexure.) The number of twists for new wire under the torsion test is from twenty to forty.

Galvanized steel wire is used for the construction of ropes which are to be used where the conditions causing corrosion are severe. Galvanizing weakens the wire. As an example, a galvanized wire gave 2.5 per cent. less tensile strength, 25 per cent. fewer bends, and 20 per cent. fewer torsions than the ungalvanized. Such ropes last longer under severe conditions. One writer gives as his experience that the life of a galvanized rope is 50 per cent. greater than that of a bright steel rope. (Mines and Minerals, February, 1912; p. 405.)

Commercial sizes of wire rope range from ¼ to ¾ in. in diameter, by increments of 1/16 in. and from ¾ to 2 in. in increments of ⅛ in.. Above 2 in. the diameter increment for different sizes is ¼ in. Flat ropes are ⅜ to ½ in. thick and from 3 to 7 in. wide in increments of ½ in.

HOISTING SPEED.

Safe hoisting speeds are determined primarily by the depth of the shaft and are for depths of 500 ft., or less, 1,200 ft. per minute; for 500 to 1,000 feet depth, 1,600 ft. per minute; for 1,000 to 2,000 ft., 2,000 ft. per minute; for 2,000 to 3,000 ft., 2,500 ft. per minute, and over 3,000 ft. up to 3,000 ft. per minute. These are conservative maximum speeds and are recommended in Bulletin 75, p. 112, of the U. S. Bureau of Mines.

THE LARGEST HOIST IN THE WORLD

The Quincy Mining Company, one of the principal propositions in the Michigan district, recently placed in operation its new Nordberg hoist at No. 2 shaft. It is believed to be the largest hoist in the world. It has a winding capacity of 10,000 ft. of 1⅝ in. rope, reaching down an inclined shaft to a vertical depth of 6,600 ft. When winding the rope down the second cone of the drum, it has a capacity of 13,300 ft., reaching to a vertical depth of 8,600 ft. The hoist operates in balance, raising a load of 20,000 lbs. per trip, and is designed for a rope speed of 3,200 ft. per minute. The drum is of the cylindro-conical type so familiar in the Lake Superior copper district. There are eight impulses per revolution, and together with the great mass of the drum, which weighs 516,000 lbs. without the shaft, practically all pulsation in the rope is eliminated. The drum is built up of 48 sections securely bolted together and thoroughly trussed within. This arrangement prevents any deflection of the drum shaft. The hoist is fully protected by an improved safety stop, whereby the throttle valve is automatically closed as the skip approaches the landing. In case of overwinding, the engine is also reversed, and the brakes are applied automatically. The hoist cannot be started in the wrong direction. Overspeed is prevented by a speed governor, which controls the cut-off cams of the valve gear. The total weight of the engine with condensing equipment is 1,765,000 lbs. The engine covers a floor space of 60 ft. by 54 ft., and stands 60 ft. high from the bottom of the foundation to the top of the drum. The weight of the skip is 10,000 lbs. The weight of the 10,000 ft. of rope is 41,500 lbs. The time required for one trip of 10,000 ft. is 4 min. 8 sec.

SAFETY DEVICE FOR STATION GATE

Mine station gates are often left open when the cage is in motion. To obviate this possibility the wiring of the signal bell at one shaft is so arranged as to make it necessary for the station gate to be securely closed before a signal can be given to the engineer.

Part of the electric circuit is attached to the gate and part to the shaft timber. Contact is made through contact plates and contact fingers, the latter being simply discarded contact fingers from an electric controller, and the former small copper plates. A snug-fitting latch is placed on the gate to hold it securely.

—Roy H. Poston, Engineering and Mining Journal.

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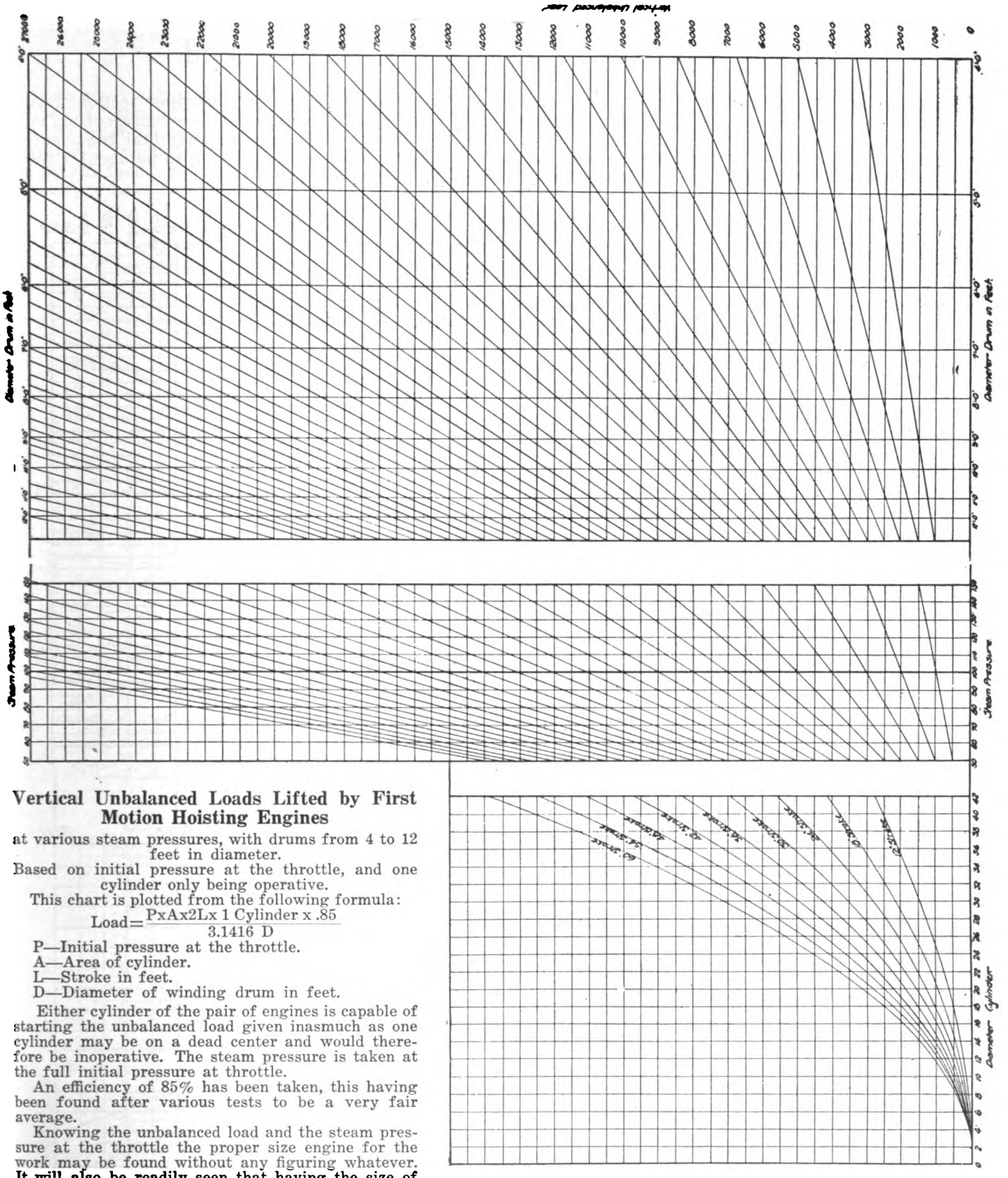

Vertical Unbalanced Loads Lifted by First Motion Hoisting Engines

at various steam pressures, with drums from 4 to 12 feet in diameter.

Based on initial pressure at the throttle, and one cylinder only being operative.

This chart is plotted from the following formula:

$$\text{Load} = \frac{\text{PxAx2Lx 1 Cylinder x .85}}{\text{3.1416 D}}$$

P—Initial pressure at the throttle.
A—Area of cylinder.
L—Stroke in feet.
D—Diameter of winding drum in feet.

Either cylinder of the pair of engines is capable of starting the unbalanced load given inasmuch as one cylinder may be on a dead center and would therefore be inoperative. The steam pressure is taken at the full initial pressure at throttle.

An efficiency of 85% has been taken, this having been found after various tests to be a very fair average.

Knowing the unbalanced load and the steam pressure at the throttle the proper size engine for the work may be found without any figuring whatever. It will also be readily seen that having the size of engine cylinders the vertical load that can be lifted by them may also be found for any steam pressure and various diameters of drum.

Example: Find the size engine capable of handling a vertical unbalanced load of 12,000 with 100 pounds steam pressure at the throttle.

The rope manufacturers give the working load for 1" rope as 6.8 tons. However, in actual practice, for this load a 1-¼" rope would probably be used and wound on, say, an 8′ 0" diameter drum.

Following the horizontal line marked 12,000 until it is intersected by the diagonal line at or about the vertical line representing an 8′ 0" diameter drum; then follow the diagonal line down to left side of chart; follow horizontal line across until it is intersected by diagonal line at or about the line representing 100 pounds steam pressure; follow this diagonal line as previously described to left side of chart; follow horizontal line until proper combination of stroke and diameter are found. For the work in hand the following engines would be satisfactory: viz: 24x48", 26x42" or 28x36"; the 24x48" size would probably be selected.

Courtesy Vulcan Iron Works.

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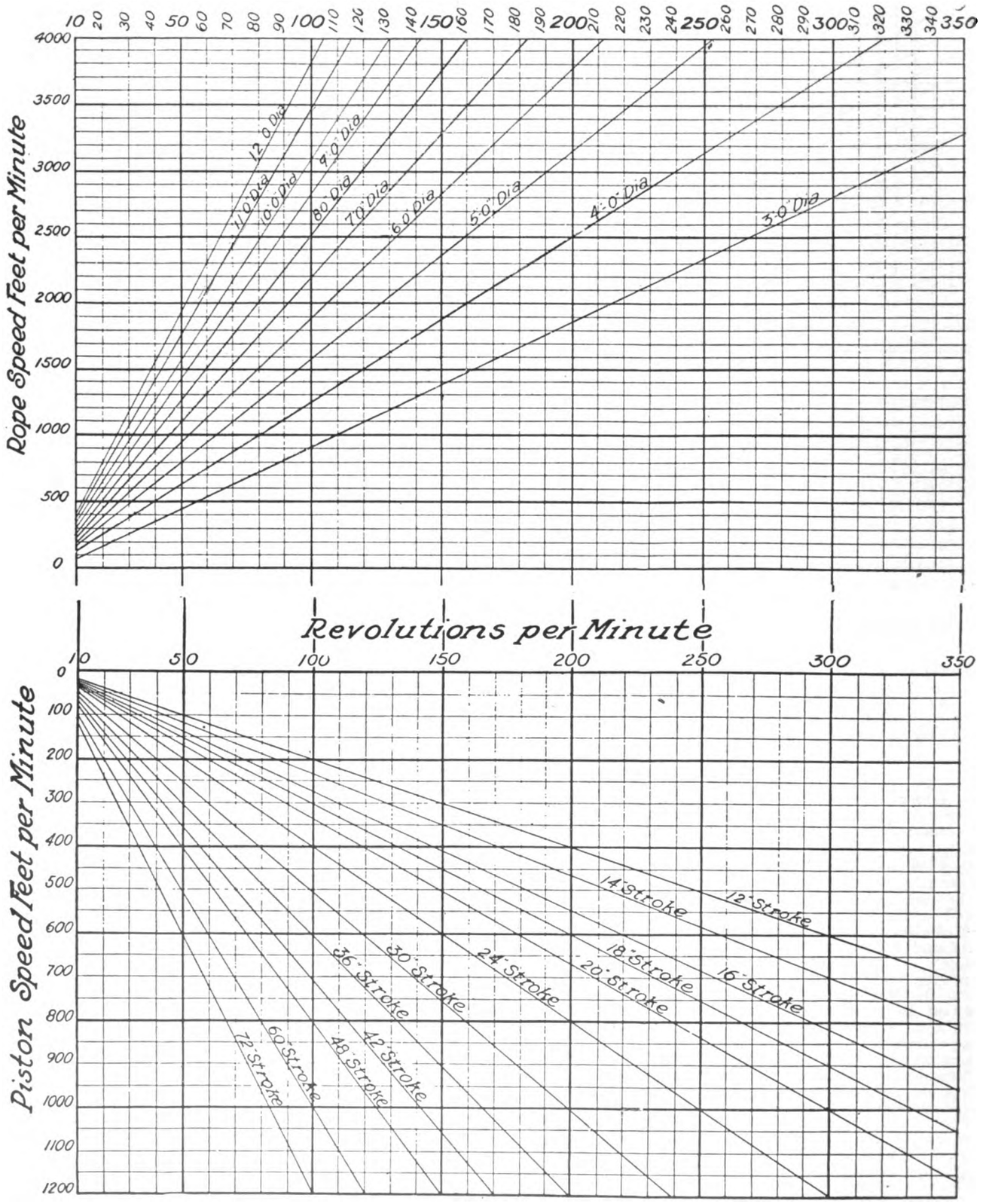
To Find Rope Speed or Piston Speed

Assume an average piston speed of 600 feet per minute.

Follow the horizontal line at 600 until it is intersected by diagonal line representing a 48-inch stroke; follow this line to the upper section until it is intersected by diagonal line representing an 8-foot drum; by following the horizontal line to side of chart the rope speed is found to be about 1,850 feet per minute.



 Courtesy Vulcan Iron Works.

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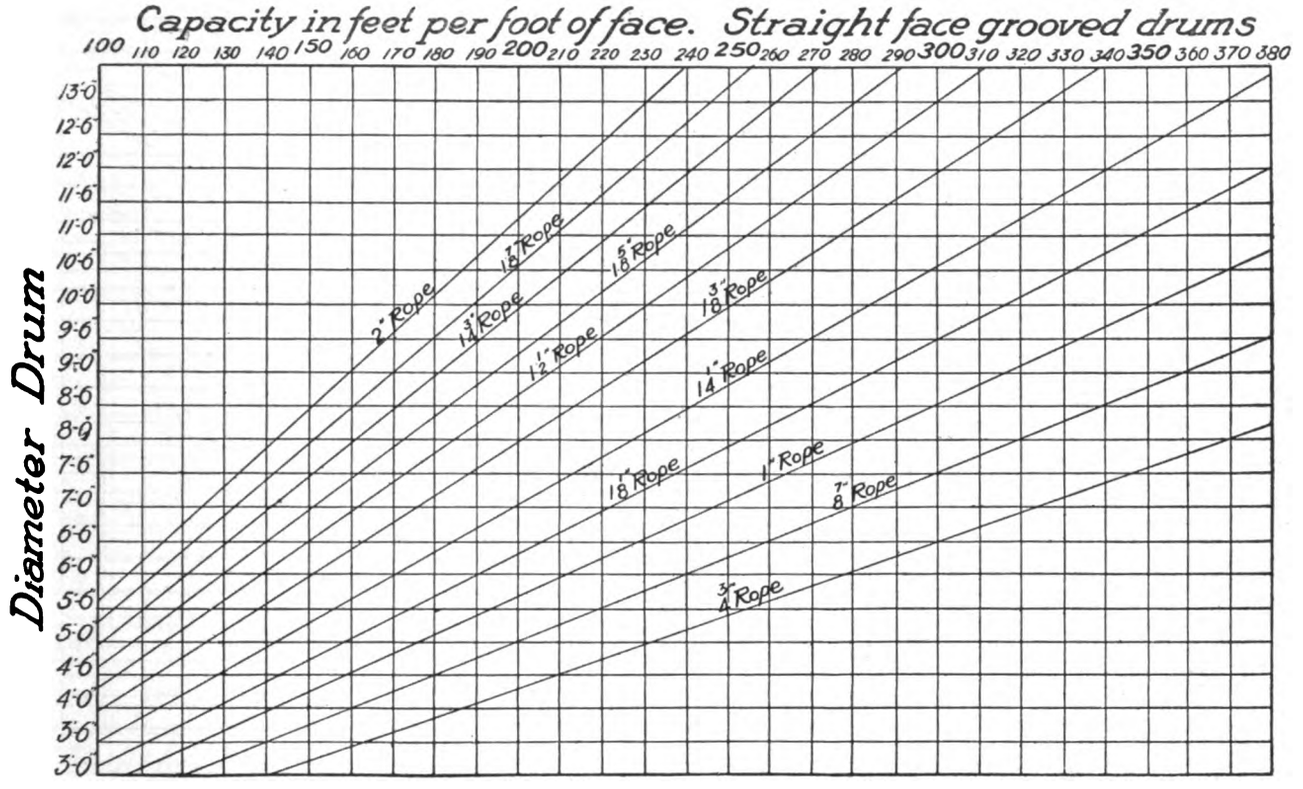
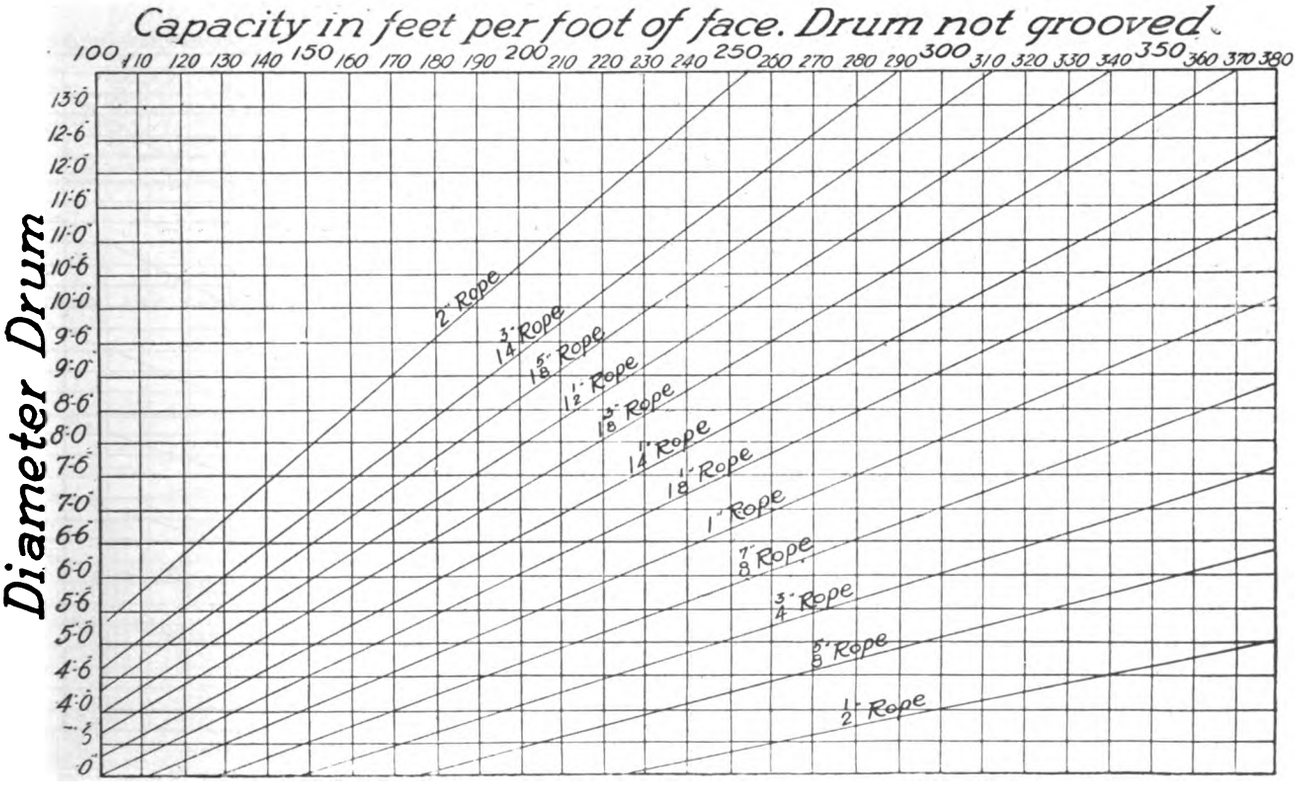
Face of Winding Drum.

As previously stated, our drum is 8′ 0″ diameter, rope 1¼″ diameter and shaft 475 feet deep. Refer to the chart below marked "Straight Face Grooved Drums." We find that an 8′ 0″ diameter drum will wind 227 feet per foot face. Our drum would therefore have to be, say, 2′ 6″ face, which would allow a sufficient number of grooves at one end of drum for fastening rope.

The chart on straight face drums not grooved, would, of course, be used in the same manner as indicated.





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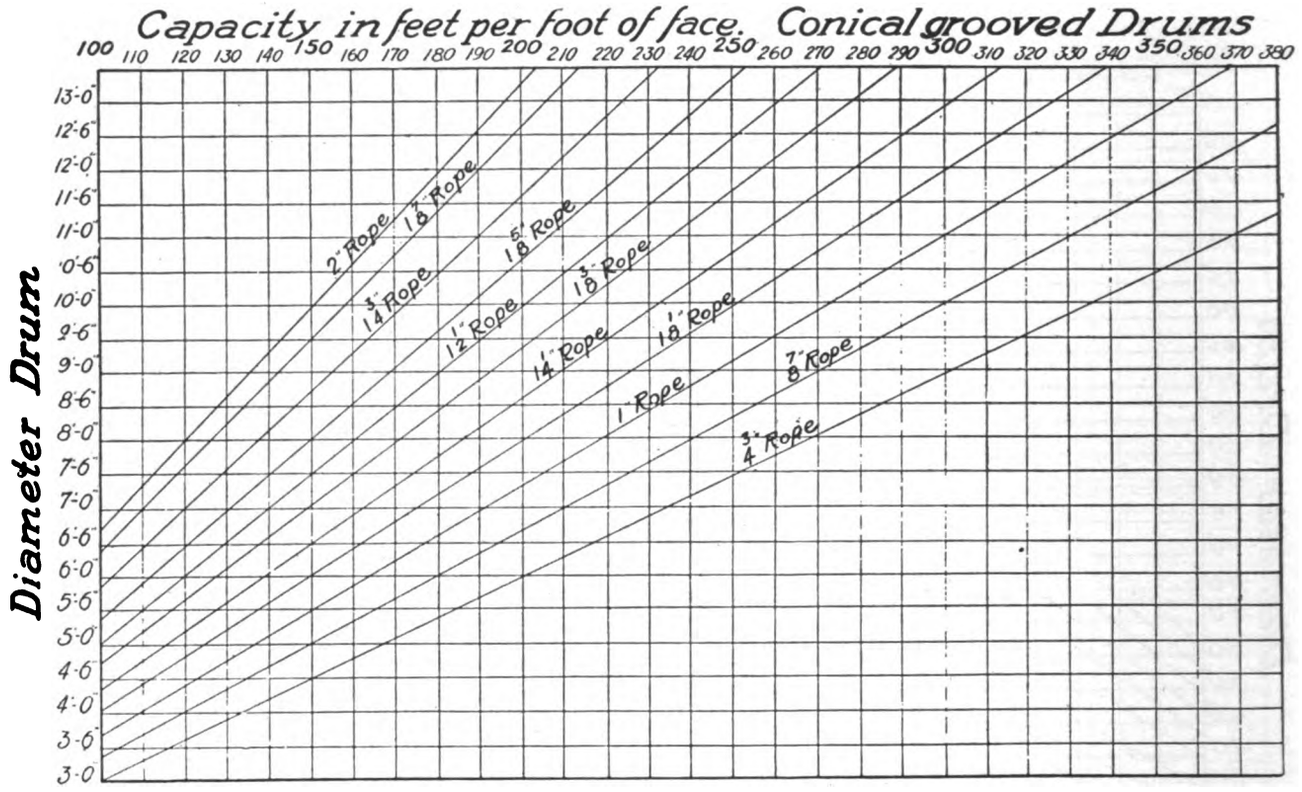
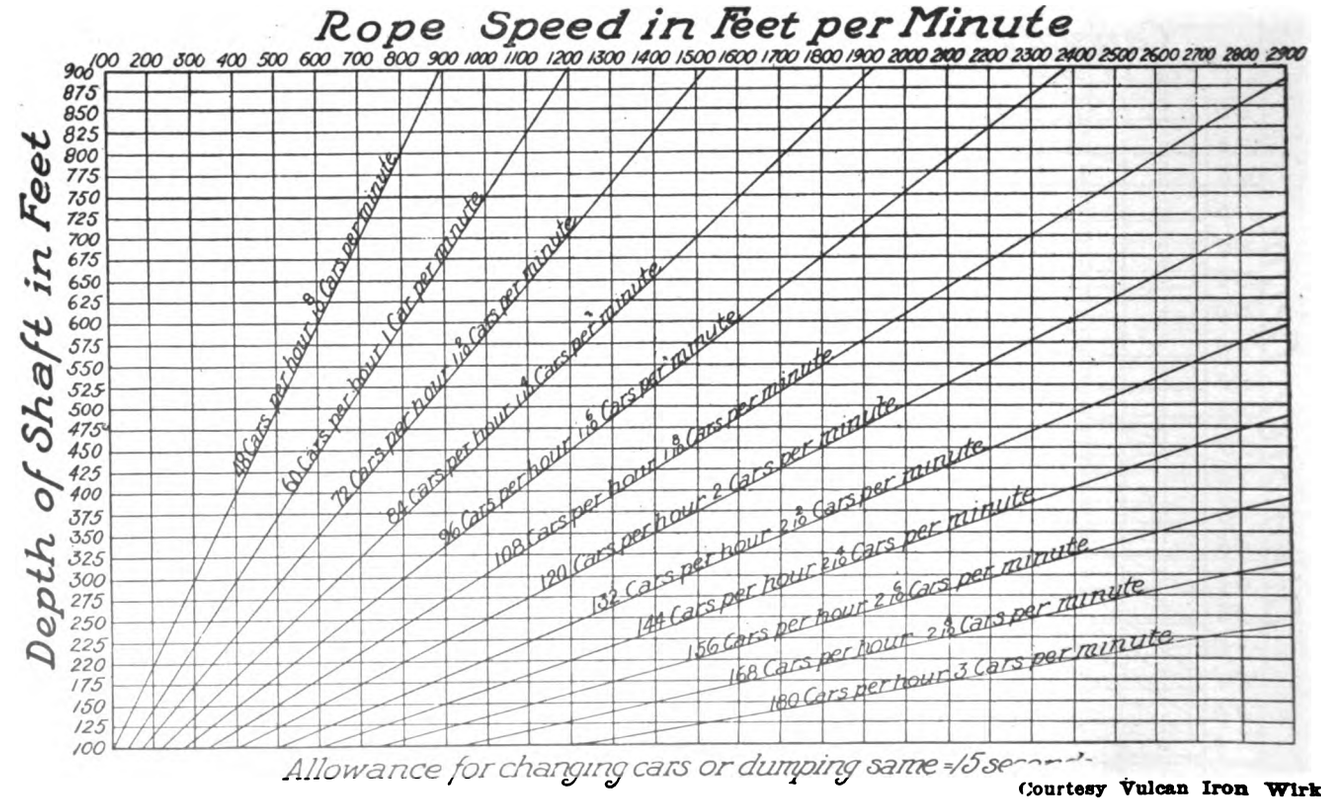
CARS PER HOUR (See Chart Below)

Assume that the shaft is 475 feet deep. We have found that the engines in question will give an average rope speed of 1,850 feet per minute, say 1,900 feet. Follow out the horizontal line until it intersects the vertical line 1900. Follow the vertical line until it intersects the diagonal line, stating cars per minute, in this case 2 cars per minute. This chart is based on an allowance of one-quarter of a minute for changing cars and a double compartment shaft.





Courtesy Vulcan Iron Wirks.

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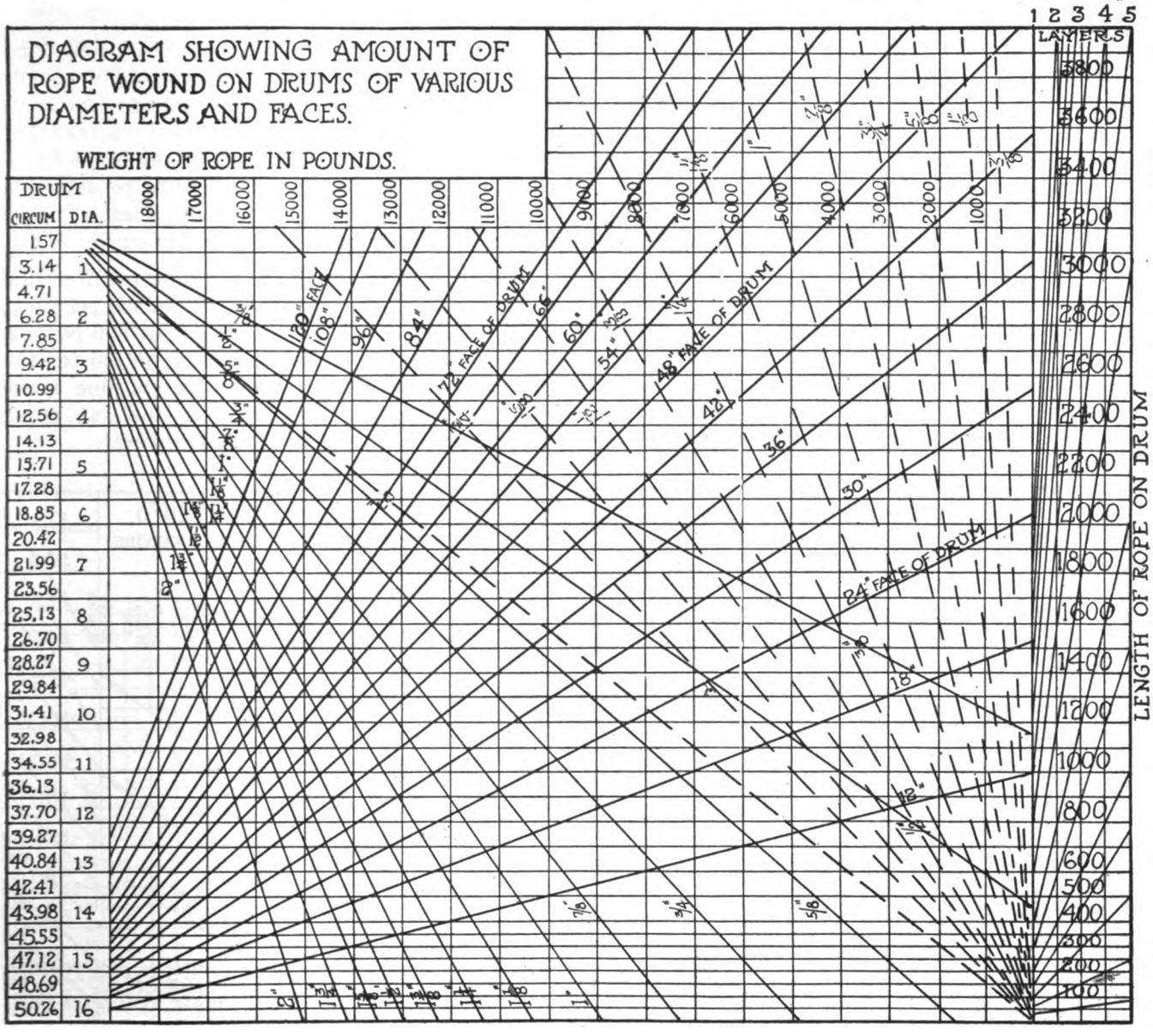

BENDING AND SAFE WORKING STRESSES FOR CAST STEEL ROPES (19 WIRES) RUNNING ON SHEAVES AND DRUMS OF VARIOUS DIAMETERS

(SAFE STRESS TAKEN ONE-THIRD OF ULTIMATE STRESS)

Size	Safe stress	120"		96"		72"		48"		36"		30"		24"	
		Bending	Working	Bending	Working	Bending	Working	Bending	Working	Bending	Working	Bending	Working	Bending	Working
⅜"	3333	283	3050	353	2980	469	2864	698	2635	924	2409	1102	2231	1366	1967
½"	5867	733	5134	913	4954	1212	4655	1800	4067	2376	3491	2829	3038	3495	2372
⅝"	9067	1506	7561	1876	7191	2485	6582	3680	5387	4847	4220	5759	3308	7095	1972
¾"	12933	2534	10399	3153	9780	4173	8760	6165	6768	8101	4832	9609	3324	11807	1126
⅞"	17333	3943	13390	4886	12447	6481	10852	9556	7777	12528	4805	14835	2498		
1"	22667	6059	16608	7528	15139	9937	12730	14614	8053	19113	3554	22589			
1⅛"	28000	8474	19526	10523	17477	13872	14128	20357	7643	26556	1444				
1¼"	33333	11452	21881	14209	19124	18713	14620	27400	5933						
1⅜"	41333	15545	25788	19272	22061	25350	15983	37028							
1½"	48000	19906	28094	24662	23338	32403	15597								
1⅝"	56000	25005	30995	30957	25043	40629	15371								
1¾"	64000	31689	32311	39203	24797	49919	14081								
2"	82667	46285	36382	57183	25484	74795	7872								

By Courtesy of the Lehigh and Wilkes-Barre Coal Company

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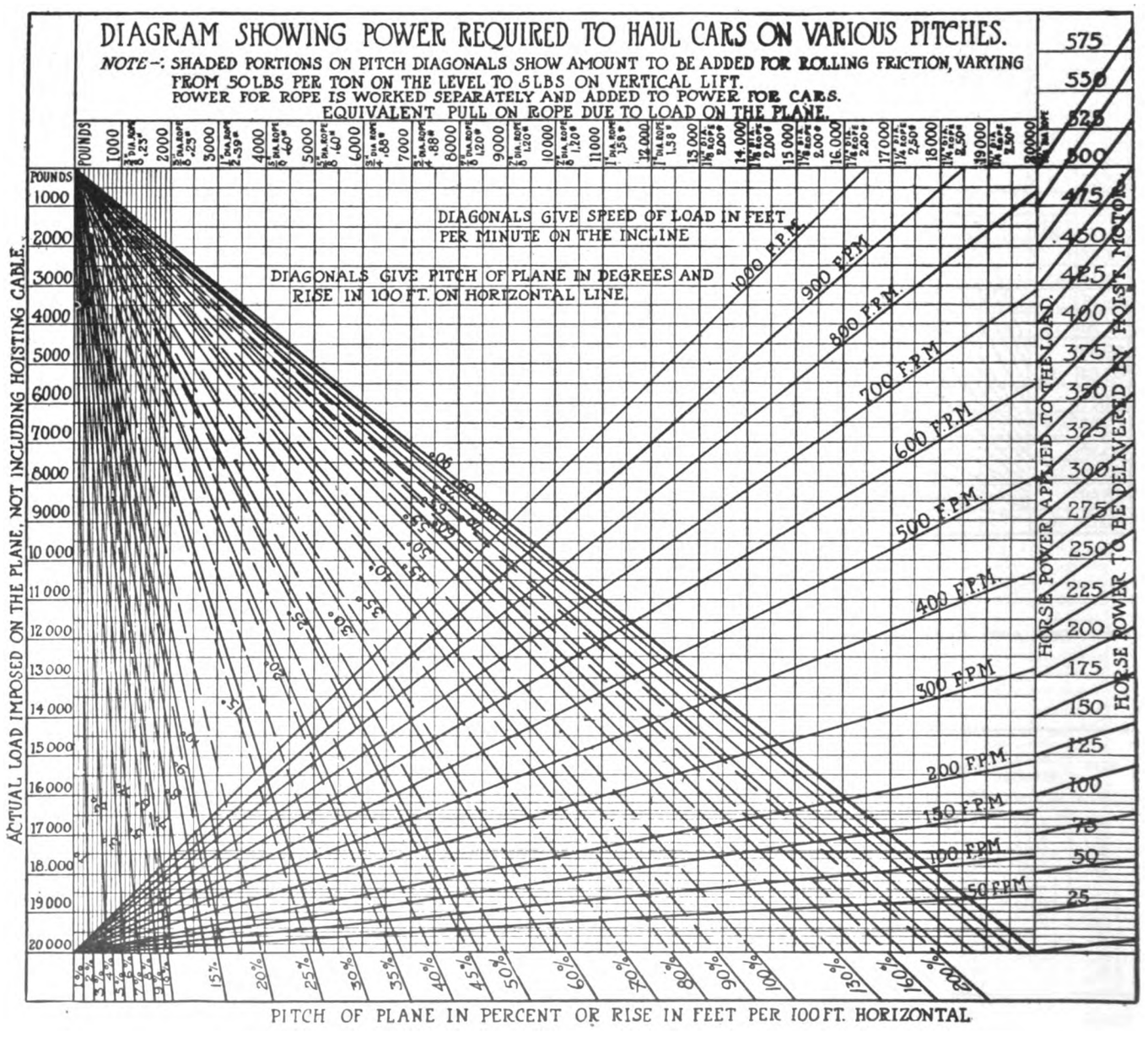
Power Required to Haul Cars on Various Pitches

It is desired to haul two loaded cars, each weighing 6,000 pounds up a plane 1,000 feet long, having a pitch of 40° from the horizontal, at a maximum rope speed of 500 feet per minute. What is the equivalent rope pull? What is the brake horse power required to handle the load?

Example: Two loaded cars weighing 6,000 pounds each equals a load of 12,000 pounds exclusive of winding rope. Follow the horizontal line representing 12,000 on the chart until it is intersected by the diagonal line representing 40°. Directly above this point of intersection will be found the rope pull, which in this case is 7,900 pounds. We also find that a ¾" rope would be satisfactory and that this size rope weighs .88 pounds per foot. Following down this imaginary line representing 7,900 pounds until it is intersected by the diagonal line representing 500 feet per minute rope speed, we read 120 horse power applied to the load, or the brake horse power required. The horse power to be delivered by this hoist motor would be 141; that is, based on an efficiency of 85% for the entire outfit.

We found that ¾" rope would be required and also that this size rope weighs .88 pounds per foot; 1,000 feet of rope at .88 pounds equals 880 pounds. By working this out the same way we did for the loaded cars we find it equivalent to nine horse power which should be added to the 141 horse power, making a total of 150 horse power.



Courtesy Vulcan Iron Works.

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TENSION ON WIRE ROPE FOR INCLINE PLANES

At	90°	the tension on rope is				2,000	lbs.	for	2,000	lbs.	load.
"	80°	"	"	"	"	1,970	"	"	"	"	"
"	70°	"	"	"	"	1,880	"	"	"	"	"
"	60°	"	"	"	"	1,732	"	"	"	"	"
"	50°	"	"	"	"	1,552	"	"	"	"	"
"	45°	"	"	"	"	1,414	"	"	"	"	"
"	42½°	"	"	"	"	1,350	"	"	"	"	"
"	40°	"	"	"	"	1,286	"	"	"	"	"
"	37½°	"	"	"	"	1,216	"	"	"	"	"
"	35°	"	"	"	"	1,148	"	"	"	"	"
"	32½°	"	"	"	"	1,074	"	"	"	"	"
"	30°	"	"	"	"	1,000	"	"	"	"	"
"	27½°	"	"	"	"	922	"	"	"	"	"
"	25°	"	"	"	"	846	"	"	"	"	"
"	22½°	"	"	"	"	764	"	"	"	"	"
"	20°	"	"	"	"	684	"	"	"	"	"
"	17½°	"	"	"	"	600	"	"	"	"	"
"	15°	"	"	"	"	518	"	"	"	"	"
"	12½°	"	"	"	"	432	"	"	"	"	"
"	10°	"	"	"	"	348	"	"	"	"	"
"	8°	"	"	"	"	278	"	"	"	"	"
"	7°	"	"	"	"	242	"	"	"	"	"
"	6°	"	"	"	"	208	"	"	"	"	"
"	5°	"	"	"	"	174	"	"	"	"	"
"	4°	"	"	"	"	138	"	"	"	"	"
"	3°	"	"	"	"	104	"	"	"	"	"
"	2°	"	"	"	"	70	"	"	"	"	"
"	1°	"	"	"	"	34	"	"	"	"	"

GRADES AND CORRESPONDING DEGREES

A	grade	of	1	foot	in 100 feet	equals	¾° or 45′
"	"	"	2	feet	" "	"	1⅛° " 1°–10′
"	"	"	2½	feet	" "	"	1½° " 1°–30′
"	"	"	3	feet	" "	"	1¾° " 1°–45′
"	"	"	3½	feet	" "	"	2°
"	"	"	4	feet	" "	"	2⅓°
"	"	"	5	feet	" "	"	3°
"	"	"	6	feet	" "	"	3½°
"	"	"	7	feet	" "	"	4°
"	"	"	8	feet	" "	"	4¾°
"	"	"	10	feet	" "	"	5¾°
"	"	"	12¼	feet	" "	"	7°
"	"	"	14	feet	" "	"	8°
"	"	"	16	feet	" "	"	9°
"	"	"	18	feet	" "	"	10 1/10°
"	"	"	20	feet	" "	"	11⅓°
"	"	"	23	feet	" "	"	13°
"	"	"	25	feet	" "	"	14°
"	"	"	26¾	feet	" "	"	15°
"	"	"	30½	feet	" "	"	17°
"	"	"	36	feet	" "	"	20° (19°-40′)
"	"	"	46¼	feet	" "	"	25°
"	"	"	57¾	feet	" "	"	30°
"	"	"	75	feet	" "	"	35°
"	"	"	84	feet	" "	"	40°
"	"	"	100	feet	" "	"	45°

Courtesy Hazard Mfg. Co.

HOISTING-ROPE SAFETY FACTORS FOR VARIOUS DEPTHS OF SHAFTS

Length of Rope	Minimum Safety Factor for New Rope	Minimum Safety Factor When Rope Must be Discarded	Percentage Reduction
500 feet or less	8	6.4	20
500 to 1,000 feet	7	5.8	17
1,000 to 2,000 feet	6	5.0	16½
2,000 to 3,000 feet	5	4.3	14
3,000 feet and over	4	3.6	10

The several factors given in the table are based on an actual safety factor of four and are made greater for shallower shafts because in them acceleration stresses and a good many of the possible extraordinary stresses are normally greater. In deep shafts it is well recognized that the spring of the rope acts to eliminate shock of starting and to decrease stresses of acceleration.

FORMULA FOR FINDING HORSE POWER, ROPE PULL AND ROPE SPEED

L = Pull on rope at drum with load at **bottom** of shaft, pounds.
= Weight of ore+rope+car+cage, or
= Weight of ore+rope+skip, or
= Weight of ore+rope+bucket.

C = Pull on rope at drum with load at **top** of shaft, pounds.
= Weight of car+cage, or
= Weight of skip, or
= Weight of bucket.

R = Rope speed of hoisting in ft. per minute.

H. P. = Maximum horse power required.

SINGLE DRUM HOISTS

$$\text{H. P. of Motor} = \frac{L \times R}{28000}$$

$$\text{Rope Pull} = \frac{28000 \times \text{H. P.}}{R}$$

$$\text{Rope Speed} = \frac{28000 \times \text{H. P.}}{L}$$

DOUBLE DRUM HOISTS

$$\text{H. P.} = \frac{(L-C) \times R}{28000}$$

Corrected for 15% friction loss motor to rope.

Note—On inclined shafts, L and C must be resolved into rope pull, in accordance with tables of "Actual Strain on Hoisting Ropes Produced by Loads on Inclined Planes." Values to nearest pound.

Courtesy Denver Engineering Works.

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ACTUAL STRAIN ON HOISTING ROPE PRODUCED BY A LOAD OF 1000 LBS. ON INCLINED PLANE

Angle of Inclination, Degrees from Horizontal	Strain on the Hoisting Rope from a Load of 1000 Pounds	Angle of Inclination, Degrees from Horizontal	Strain on the Hoisting Rope from a Load of 1000 Pounds
2°50′	49 lbs.	33°5′	546 lbs.
5 45	100	36 55	601
8 35	149	40 20	647
11 20	196	42	669
14 5	243	45	707
16 45	289	47 45	740
19 20	331	52 30	793
21 50	371	58	848
24 15	410	63 30	895
26 35	448	71 30	948
28 50	484	84 20	995

For any angle not given the stress of the rope can be calculated as follows:

Let S = the stress in pounds
a = angle the incline makes with horizontal
Then S = 1000 sin. a

To correct for rolling friction add 40 cos a.

Courtesy Denver Engineering Works.

WIRE ROPE DATA

HOISTING

For vertical shaft work it is customary to use almost universally the 6x19 construction rope. The cages are usually arranged in pairs so that as one is lowered the other is raised, this being known as the balanced hoist system. Two types of hoisting drums are in common use, the flat drum and the conical drum, the latter being designed to give a slower starting speed when the cage is lifted from the bottom of the mine.

The simplest arrangement is for the ropes to pass directly from the drum to two head sheaves carried on a wooden or steel tower, each sheave in line with the center of that part of the drum on which the rope has to wind. It is customary with either the flat or conical drum to attach one rope to the under side of the drum and the other rope to the top of the drum, leaving several turns on the drum when the cage is resting on the bottom of the mine shaft. The names "underwind" and "overwind" are applied to these two ropes.

Conical drums are used more frequently on shorter mine ropes, but unless the smaller end has nearly as large a diameter as would be used for a flat drum, the rope service may not be much better than with a flat drum. It is a debatable point as to which type of drum is the better.

We recommend wherever possible that installations of mine hoist ropes be made with as few bends as possible. In case a shaft has to be changed or if the engine room cannot be located, so as to carry the rope, a turn sheave may be used with suitable lead and intermediate supporting sheaves to carry the rope.

HAULAGE

Mine haulage systems are very widely different one from another, so much so that it may almost be said that there are hardly any two alike. At the same time there are in common use three leading systems known respectively as

1. **Endless Haulage Rope System.**
2. **Tail Rope System.**
2. **Gravity Inclined Plane.**

1 The endless system consists of a wire rope, usually 6x7 construction, spliced endless with small cars gripped on to the rope at regular intervals either singly or in groups of two or three. Two kinds of drum driving arrangements are usually employed, known as the elliptical and the figure 8 style respectively. The elliptical arrangement is preferable to the figure 8 as the rope in the latter case is subjected to reverse bending on the drums. Suitable slip rings should always be used on drums to equalize the tension of the different winds of rope, and a tension carriage with counterweight is also necessary. Position of engine and driving drums is usually dependent upon the location of pit mouth. Slow speed of about 3 to 4 miles per hour is the average of this system.

2. Tail rope systems consist of two ropes known respectively as head line and tail line, the latter usually being about double the length of the former. Each rope is carried upon a separate drum and it differs from the endless system in that its operation is intermittent and the cycle of operations is for the head line to pull out a trip of about fifty loaded cars at a speed of about ten miles per hour. The time taken for the trip is dependent upon the length of the headline. The tail line is always attached to the rear car of the trip and as soon as the loaded cars have run to the tipple by gravity, an empty trip of cars is pulled back into the mine by the tail line while the head line is at the same time attached to the front end of the train. The train of loaded cars or empty cars as the case may be, is thus always under perfect control whether coming from the mine or returning to it.

Courtesy American Steel & Wire Co.

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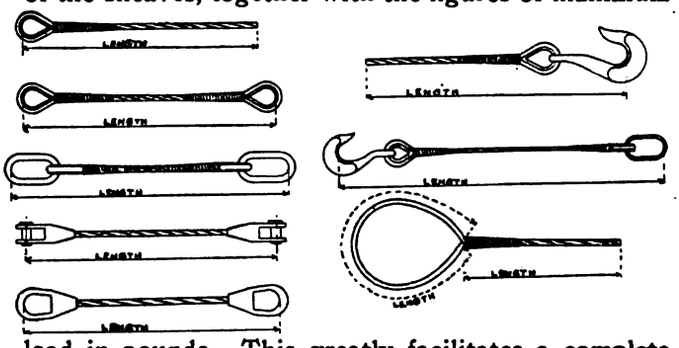
How to Order Wire Rope

State length, size, diameter (or circumference), quality, number of strands, number of wires in the strand, and whether hemp center or wire center is wanted, also whether bright or galvanized is desired, e. g., 750 feet long, 1⅛ inches in diameter, plow steel hoisting rope, six strands, nineteen wires, hemp center, one piece.

If rope is to be equipped with thimbles, sockets, hooks, links, loops or other fittings, state the length from the pull of thimble, socket, hook, link, loop, etc., to end of the rope. Where fittings are to be put on each end, be sure and state the length from pull to pull of fittings.

If in doubt as to the material to be used, the conditions under which the rope operates should be given or a sample of rope that is satisfactory submitted so that the proper quality and construction may be furnished.

If possible, submit a rough sketch with the order, or inquiry showing the size and relative position of the sheaves, together with the figures of maximum



load in pounds. This greatly facilitates a complete understanding of the requirements which the rope must fill.

Inspection, Care, Lubrication and Handling of Wire Rope

As a rule, mining companies carry spare ropes on hand which should be stored in a thoroughly dry place. If they are put in a damp place, or left exposed to the weather, they will be more or less injured, unless the rope is thoroughly lubricated, and even in this case it is far better policy to have the rope well protected.

Hoisting and haulage ropes are shipped on reels and unwinding is a simple matter. If the reel is heavy, a large diameter pipe may be passed through its center, which will then serve as an axis. Each end of the pipe is then rested on a brace, or other support, at such a height that the reel is lifted off the ground and is free to turn about its center. Ropes of shorter lengths are sometimes received in a coil and great care must be taken to prevent kinks in unwinding. The rope should be rolled along the ground like a hoop, and under no consideration should be taken off coil by coil.

A rope should be carefully inspected when it is installed in order to determine whether or not it has been injured in transit, and, moreover, for the purpose of detecting imperfections in manufacture. Manufacturers would much rather be advised of anything of this description than to have the rope installed and complaints made afterwards.

Hoisting ropes should be examined daily, especially where men are brought in or out of the mine. In most states this examination is made compulsory. Frictional wear and corrosion externally, along with abrasion of the wires and deterioration of the core internally, due to use and conditions, are continually taking place. When this wear has progressed to such an extent that the cross sections of the wires are reduced and their strength materially lessened, broken wires begin to appear along its surface. As wearing continues, the number of breaks increases. This is a sure indication of the diminished strength of the rope, since the broken wires are the result of the weakened condition.

As long as the breaks are far apart, little effect is produced on the strength of the rope, since the frictional tenacity is not impaired by a few breaks far removed from each other. But when several breaks occur close together, the strength is much more affected. It will thus be seen that the number of breaks in the rope and the relation they bear to each other provides an index of the safe condition of the rope.

All ropes should be lubricated, and in wet shafts the rope should be well protected from the entrance of moisture. In some instances ordinary black oil is used. This has little or no value, as it does not cling to the surface, penetrate to the core, nor resist the effects of moisture or other damaging elements. An efficient wire rope lubricant must be free from any material that will attack the constituent parts of the rope, must remain soft and pliable under all atmospheric conditions, and must not be subject to evaporation. It must be insoluble in water and must be unaffected by the acids contained in mine water. It must, moreover, have the property of penetration, enabling it to reach every wire and each strand into the core. It must have great adhesiveness and must not peel.

As a general rule, hoisting ropes give out at a point near the socket. As the slack is taken up at the beginning of hoisting there is considerable vibration, and as the length of rope constantly diminishes during the hoist, the effects of this swaying of the rope are concentrated at or about the socket. Crystallization of the wires takes place, and in order to eliminate this weakened section a portion of the rope should be cut off at regular intervals. Wire ropes will always stretch after being put into service, and unless ample provision is made at the cage connections for taking up the increase in length, the excess may have to be taken up on the drum or else the rope cut and re-socketed.

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RULES FOR THE INSTALLATION AND MAINTENANCE OF HOISTING ROPES

1. Sockets are recommended for all rope attachments; when properly made they will develop the full strength of the rope.

2. All socket attachments should be made with zinc.

3. All wires should be thoroughly cleaned and fluxed.

4. All wires should be separated and straightened.

5. Four good seizings of iron wire should be placed on the rope, the first at a point from the end of the rope equal to the length of the socket basket.

6. The zinc should be poured when its temperature will cause a pine stick to char and ignite.

7. When the surrounding temperature is less than 50° F., the socket should be warmed before pouring the zinc.

8. At the top of the socket there is a point which is rigid where vibration is arrested suddenly, causing fatigue at that point. Therefore, the rope should be resocketed every three months for a speed of 1,000 feet per minute or less, and every two months for higher speeds.

9. When resocketing, about 6 feet of rope should be cut off the end and examined for internal corrosion. This length is specified because this part of the rope is subject to the most rapid depreciation. It is advisable, since it brings another section of rope on the head sheave when the cage is stationary.

10. All new hoists should have drum capacity enough to take care of the surplus rope necessary to permit resocketing and allow a minimum of three laps to remain on the drum when the rope is fully out.

11. Clips are not advisable for fastening the rope to the cage, as they do not develop the ultimate strength of the rope and when placed incorrectly may damage the rope to a great extent.

12. Catalog strengths are to be used in fixing the proper load capacity of a rope.

13. The factor of safety is not to be less than five for vertical shafts.

14. The factor of safety is not to be less than six for slopes and inclines.

15. The head sheaves shall be at least 60 times the diameter of the rope for 6x19 ropes and 90 times the rope diameter for 6x7 ropes.

16. All knuckle sheaves on slopes or inclines that change the direction of the rope 20° or more shall have diameters as specified in article 15.

17. All ropes shall be inspected daily.

18. All ropes should be thoroughly lubricated.

19. The lubricant shall consist of oils and greases that will penetrate between the wires and the strands. The rope shall not be coated with any lubricant that hardens on the outside, as this cracks with bending over the sheaves and drums and when exposed to moisture allows the moisture to penetrate to the center and cause internal corrosion.

20. Head sheaves must be in perfect alignment with slope or incline.

21. All sheaves must run true and be kept in perfect condition.

22. All sheaves shall have grooves that support the rope for one-third of the rope diameter.

23. All metal surfaces on obstructions in contact with the rope must be eliminated.

24. On inclines and slopes the moving rope must be kept from contact with the rails and other metal unless this be impossible, when roller equipment must be installed to the best possible advantage.

Bulletin 75, U. S. Bureau of Mines.

WIRE ROPE SPLICING

In ordinary wire rope practice, there are three classes of splices, i. e., the "End-to-End," the "Endless," and the "Thimble" splice.

END-TO-END splicing is the process of attaching one rope to another, making one long rope out of the two, by interlocking the strands as shown by the accompanying illustration. Ropes of similar construction can usually be spliced in this way, even though they be made by different manufacturers. However, it is apparent that a right lay rope could not be spliced with a left lay one. In making this splice a certain amount of the rope is used up, and this should be taken into consideration in ordering an endless rope. The shrinkage in length ranges from 16 feet for rope 3/8 inch diameter to 44 feet for ropes of 1½ inch diameter. Ropes of long lay may be spliced End-to-End, but the strands are more difficult to tuck in.

The ENDLESS splice is made in exactly the same manner as the End-to-End splice, the only difference being that instead of interlocking the ends of two different ropes, we interlock the ends of the same rope. In this splice approximately the same amount of rope is used as in the End-to-End.

The THIMBLE splice is the process of forming a loop into the end of a rope and then interlocking the strands, the loop usually containing a thimble or other fitting. Only a foot or two is used up in this splice.

Directions for Splicing Wire Rope

The tools required for splicing are a small marlin-spike, nipping cutters, and either clamps or a small hemp rope sling with which to wrap around and untwist the rope. If a bench vise is accessible, it will be found very convenient for holding the rope.

In splicing rope, a certain length is used in making the splice. An allowance for this must be made in ordering the rope. The table below gives these lengths for different sizes of ropes:

Diameter of Rope in Inches	Extra Length Allowed for the Splice Feet	Diameter of Rope in Inches	Extra Length Allowed for the Splice Feet
3/8	16	1	32
1/2	16	1 1/8	36
5/8	20	1 1/4	40
3/4	24	1 1/2	44
7/8	28	...	..

Having measured carefully the length the rope should be after splicing and marked the points M and M′ (Fig. 1), unlay the strands from each end E and E′ to M and M′, and cut off the hemp center at M and M′, and then:

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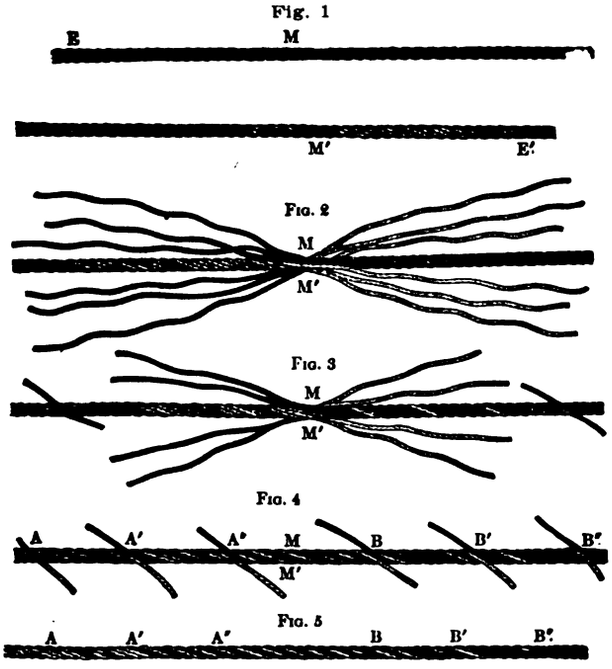
First. Interlock the six unlaid strands of each end alternately, cutting off the hemp centers at M and M′ and draw wire strands together, so that the points M and M′ meet, as shown in Fig. 2.

Second. Unlay a strand from one end, and following the unlay closely, lay into the seam or groove it opens the strand opposite it, belonging to the other end of the rope, until there remains a length of strand equal in inches to the length of splice EE in feet, e. g., the straight end of the inlaid strand A on ½-inch rope equal 16 inches for 16-foot splice. Then cut the other strand to about the same length from the point of meeting, as shown at A (Fig 3).

Third. Unlay the adjacent strand in the opposite direction, and following the unlay closely, lay in its place the corresponding opposite strand, cutting the ends as described before at B (Fig 3).

The four strands are now laid in place terminating at A and B, with the eight remaining at M and M′, as shown in Fig. 3.



It will be well after laying each pair of strands to tie them temporarily at the points A and B.

Pursue the same course with the remaining four pairs of opposite strands, stopping each pair of strands so as to divide the space between A and B into five equal parts, as shown in Fig. 4, and cutting the ends as before.

All strands are now laid in their proper places with their respective ends passing each other, as shown in Fig. 4.

All methods of rope splicing are identical up to this point; their variety consists in the method of securing the ends. One good way is as follows:

Fig. 6 Fig. 7

Clamp the rope either in a vise at a point to the left of A (Fig. 4), and by a hand clamp applied near A open up the rope by untwisting sufficiently to cut the hemp core at A, and, seizing it with the nippers, let your assistant draw it out slowly. Then insert a marlin-spike under the two nearest strands to open up the rope and starting the loose strand into the space left vacant by the hemp center, rotate the marlin-spike so as to run the strand into the center. Cut the hemp core where the strand ends, and push the end of hemp back into its place. Remove the clamps and let the rope close together around it. Draw out the hemp core in the opposite direction and lay the other strand in the center of the rope in the same manner. Repeat the operation at the five remaining points, and hammer the rope lightly at the points where the ends pass each other at A, A′, B, B′, etc., with small wooden mallets, and the splice is complete, as shown in Fig. 5.

If a clamp and vise are not obtainable, two rope slings and short wooden levers may be used to untwist and open up the rope.

A rope spliced as above will be nearly as strong as the original rope, and smooth everywhere. After running a few days, the splice, if well made, cannot be pointed out except by the close examination of an expert.

Courtesy American Steel and Wire Co.

SPECIMEN FORM SHEET FOR HOISTING PLANT

(Information Desired by Manufacturers)

Company .....

Location .....

Type of Hoist, steam or electrical.....

Geared or first motion.....

Single or double drum.....

Load
- Weight of skip.....
- Weight of cage.....
- Weight of car.....
- Weight of ore.....
- Weight of rope.....

Average speed desired.....

Shaft—Vertical or inclined.....
- Degree of inclination from horizontal.....
- Single or double compartment.....
- Size of compartments.....
- Present depth .....
- Ultimate depth .....

Size and kind of rope to be used.....

Cages—In balance or independent.....

Type of clutch desired.....

Type of brake desired.....

Steam pressure available at engine.....

Corliss or slide valve.....

Electric current available at motor—
- Alternating or direct.....
- Voltage .....
- Phase .....
- Cycle .....
- Time in operation.....
- Time at rest.....

Remarks.....

.....

Signature ..... Date .....

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*TABLE OF THE MORE IMPORTANT SIGNALS PRESCRIBED BY LAW OR IN COMMON USE IN THE PRINCIPAL METAL-MINING STATES AND DISTRICTS

State.	Signal prescribed by—	1 bell.	2 bells.	3 bells.	4 bells.	5 bells.	6 bells.	7 bells.	8 bells.	9 bells.	Other signals of importance.	
											Number of bells.	Meaning.
Arizona	State code	Hoist-stop-release shaft conveyance.	Lower	Men on	Steam on (or off)	Blasting	Air on (or off).	Danger				
California	do	Hoist—stop	do	do	Start (or stop) pump.	Send down tools.	Send down timbers.	Foreman wanted.			2-2-1	Blasting.
Colorado	do	do	do	do				Accident—move by verbal orders only.			3-2-1	Do.
Idaho	do	do	do	do	Blasting					Danger		
Michigan:												
Dickinson County.	In common use.	Stop	do	Hoist	Lower slowly		Hoist slowly				1-2	Lower men.
Gogebic County.	do	do	do	do	Lower men		Hoist men				1-3	Hoist men.
Iron County.	Recommended by committee of mine managers.	do	do	do	Lower slowly	Hoist slowly	Hoist to shaft collar.				a 8-4 a 8-6 1-3	Lower men. Hoist men. Hoist rock.
Keweenaw County.	In common use.		do	do			Men on					
Marquette County.	Used by leading company.	Stop	do	do	Lower men	Hoist men	Blasting	Steam on (or off).	Air on (or off).	Danger	10	Fire.
Minnesota:												
Crow Wing County.	In common use.	do	do	Hoist ore or empty cage.	Lower men on cage. Lower skip slowly.	Hoist rock	Hoist cage with men. Hoist skip slowly.	Start compressor.	More air.	Stop compressor.		
St. Louis County.	do	do	do	Hoist	Lower slowly	Hoist slowly to shaft collar.	Hoist slowly					
Missouri: Joplin district.	do	Hoist men—stop.	do	Call conveyance for men.	Pull steel							
Montana	State code	Hoist—stop	Lower men.	Hoist men.	Blasting	Steam on	Steam off	Air on	Air off	Danger		
Nevada	do	do	Lower	Men on	do					do		
New York	Used by a salt company.	Stop	Hoist cage at usual speed.	Lower cage at usual speed.	Hoist slowly	Lower slowly	For use of shaft men only (as in repairs).					
Do	Used by large iron mining company.	Hoist—stop	Lower	Men on								
Oregon	State code	do	do	do	Move slowly	Send down tools.	Send down timber.	Accident			3-2-1	Blasting.
South Dakota	do	do	Lower men.	Hoist men.	Blasting	Steam on	Steam off	Air on	Air off	Danger		
Utah	In common use.	do	Lower	do	Start or stop pump.	Send down tools.	Send down timber.	Accident—move by verbal orders only.			3-2-1	Do.
Wyoming	State code	do	do	do				do			3-2-1	Do.

a When repeating system is not used.

*Bulletin No. 15, U. S. Bureau of Mines.

FORMULA FOR STRENGTH OF ROPE

The Bureau of Standards laboratories in the Department of Commerce have made tests from which it has been possible to deduce a formula that will give the strength of ropes.

For three-strand, regular lay manila rope from ½-in. to 4½-in. in diameter, the following computation will give the breaking load of the rope:

The average breaking load in pounds equals 5,000 multiplied by the diameter of the rope in inches, multiplied by the diameter of the rope increased by one.

This will give, of course, the average maximum weight that the rope will hold, but the working load or the load that a contractor or safe-hauler may apply with proper safety and precaution would be considerably less than the load given by the formula.

Other data on rope are contained in Technologic Paper of the Bureau of Standards No 198, by A. H. Stang and L. R. Strickenberg, which has just been issued.

—Engineering and Mining Journal, December 3, 1921.

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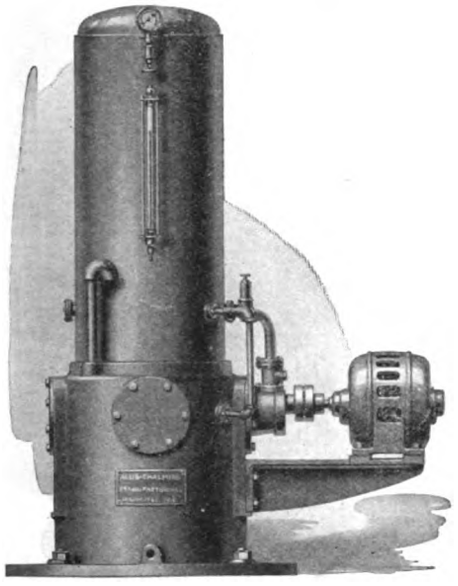
Allis-Chalmers Manufacturing Company

MILWAUKEE, WISCONSIN

For Branch Offices and Other Products, See Page 168

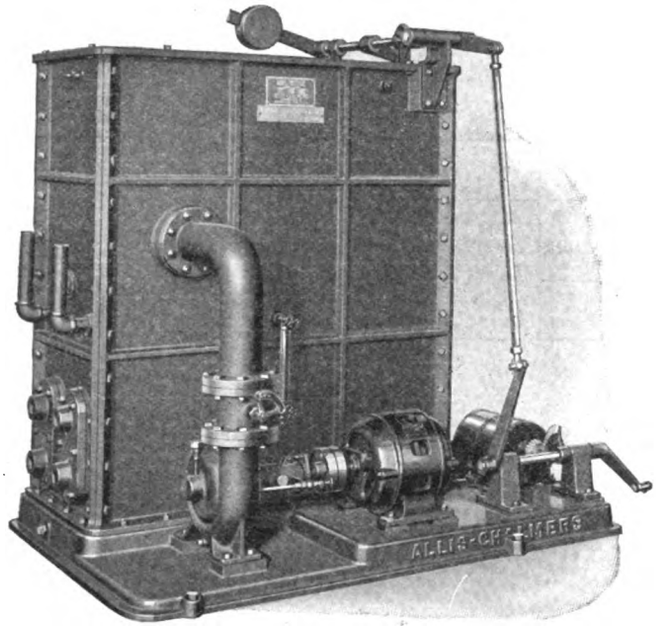
Steam and Electric Hoists

Allis-Chalmers Manufacturing Company is in a position to offer you all types and sizes of steam and electric hoists. It has in successful operation electric hoists for all conditions of service, both with induction motor drive and with direct current motor and flywheel equalizing sets.

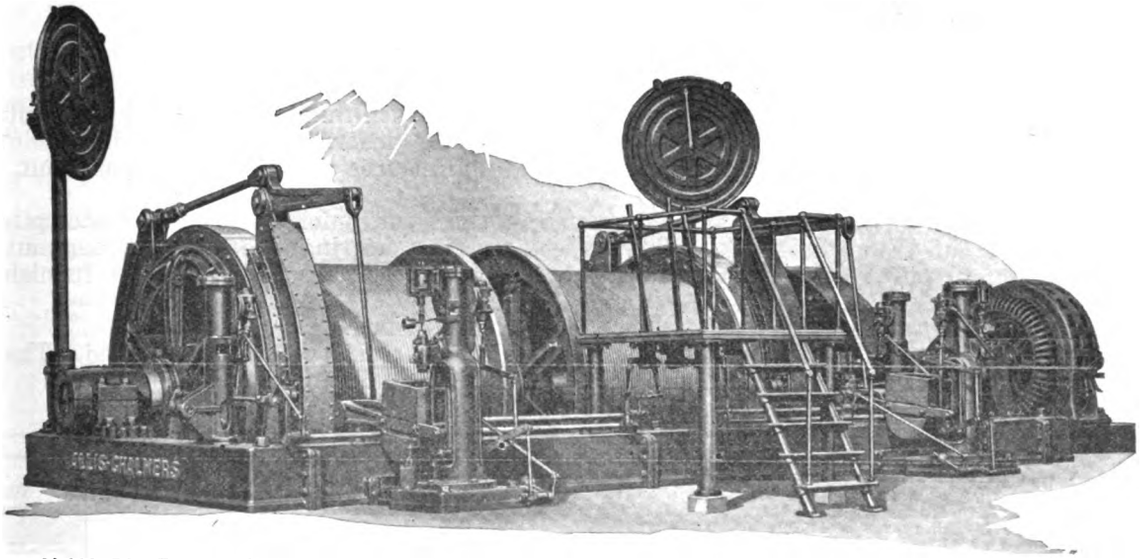


Oil Pressure System—Motor Direct Connected

The hoists are equipped with the most improved safety features to completely protect the hoist in every emergency. The Company's engineering organization is at the disposal of prospective purchasers without obligation. They will make recommendations as to the type of hoist best suited for your particular requirements. This is the only company which builds the entire hoist with motor and control in one plant under direction of one engineering and one manufacturing organization.



Allis-Chalmers Liquid Controller for Mine Hoists



23,300 Lb. Rope Pull Double Drum Ore Hoist. Structural Steel Parallel Motion Post Brakes, Brown Clutches, Aux. Oil Engines, Oil Pressure System. Complete Safety Features. 750 H. P. Induction Motor. Liquid Controller.

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THE ENGLISH TOOL & SUPPLY CO.

Iron Works Department
KANSAS CITY, MO., U. S. A.

SAMSON

SAMSON

HOISTS

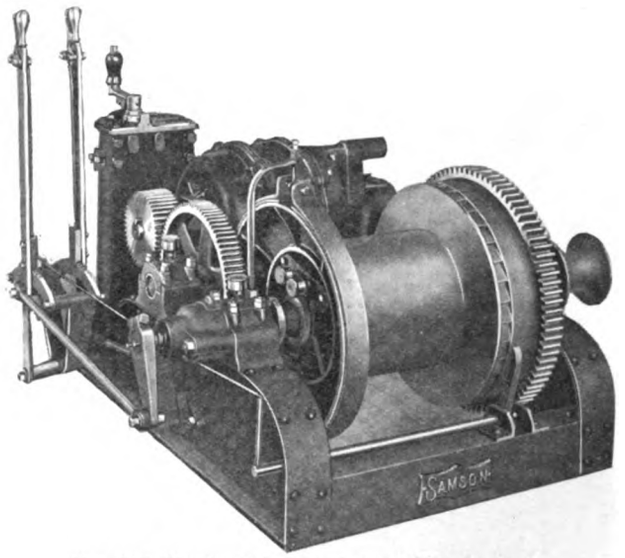
For Electric, Steam, Gasoline or Oil Engine Power

No. 202 Hoist frame is of fabricated steel. This machine is much lighter than a cast iron hoist, and is equally strong. The cost of transportation, due to its light weight, is comparitively small. The hoist gears are semi-steel. The motor pinion is rawhide. The teeth of the gears are cut on automatic machines, thus insuring smooth, quiet running and long life. The drum hubs are fitted with phosphor bronze bushings. Both friction clutch and band brake are hand operated, the operating levers being conveniently arranged and provided with quadrants and locking pawls.

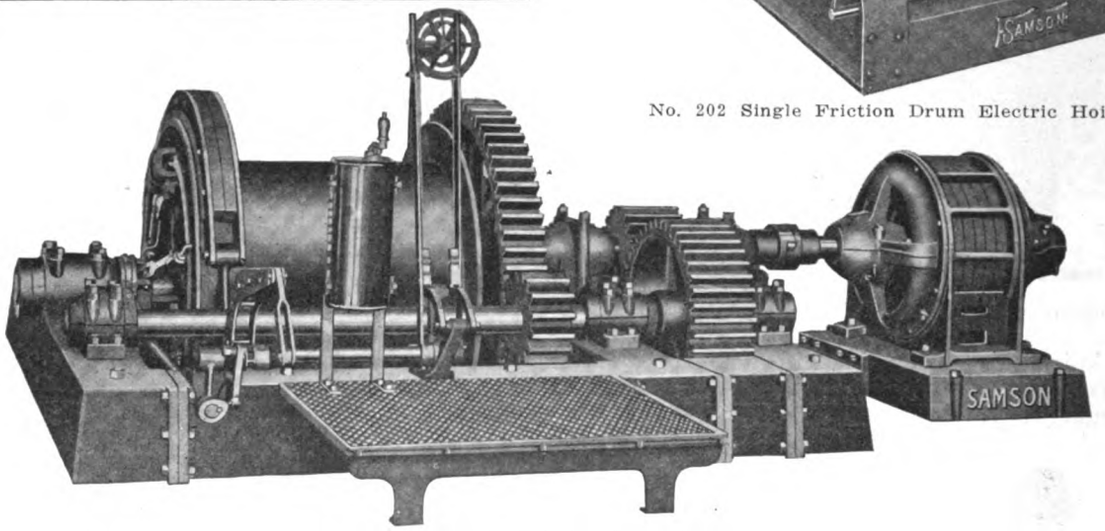
For driving these hoists we furnish either direct current or alternating current motors. The controllers used are usually of the drum type, as illustrated.

TABLE OF SIZES, ETC.

Hoisting Duty	Drum			Size of Rope, Inches	Weight, Pounds
Load or Rope Pull, Pounds	Dia. Inches	Length Between Flanges, Inches	Ft. of Rope Drum Will Hold		
2500	16	18	1500	½	2300



No. 202 Single Friction Drum Electric Hoist



Nos. 144½-146½ Single Friction Drum Electric Hoists

These hoists are equipped with band friction clutches and post brakes; if specified differential band brake can be furnished. The frames are sectional, of the box girder type with machined joints. The design brings shaft bearings and drum near the ground and insures a rigid and compact unit, suitable for hard and continuous mine service.

Spur gears are used, of a special mixture of cast iron, the hoist pinion is steel, the motor pinion rawhide; all teeth are cut from the solid. Where specified, steel herringbone gears throughout will be furnished instead of spur gears. Where hoisting duty permits these hoists can be furnished with single reduction gears.

Gear guards of heavy steel plate (not illustrated) are furnished.

The electrical equipment is alternating current, or direct current as may be required. The type of controller furnished will depend upon the size of motor used and hoisting conditions.

TABLE OF SIZES, ETC.

Hoist Number	Hoisting Duty	Drum			Size of Rope, Inches	Approx. Floor Space, Inches	Weight, Pounds
	Load or Rope Pull, Pounds	Diameter, Inches	Length Between Flanges, Inches	Feet of Rope Drum Will Hold			
144½ 146½	7000 10000	42 54	30 30	3500 3300	⅞ 1	130x114 204x144	15,700 33,200

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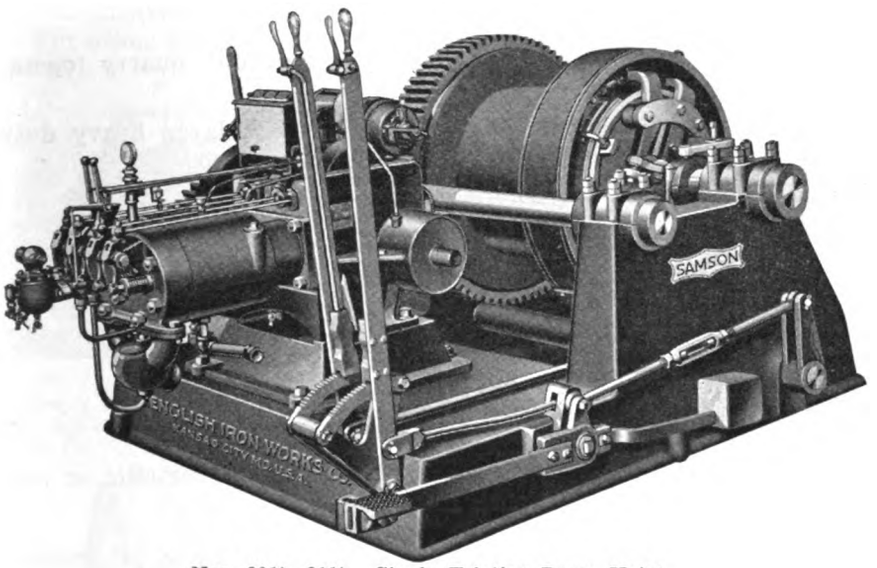
SAMSON

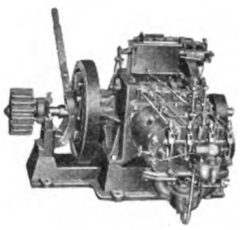
Gasoline—Kerosene Engine Hoists

These hoists, one of which is illustrated below, are equipped with wonderfully simple and rugged two-cylinder twin motors, especially designed for the demands of hoisting duty and guaranteed to burn either kerosene or gasoline with equal efficiency.



Nos. 80½, 81½. Single Friction Drum Hoist

The motor will "pick up" instantly from no load to full load without misfiring, without throttling and without delicate adjustment of the carburetor. This is especially advantageous when doing work with quick power changes such as hoisting work.



The Motor

Under any conditions they give as efficient service as can be obtained from steam or electric hoists.

Our hoists Nos. 80½, 81½, are made with one-piece frames. The hoist with its kerosene-gasoline motor is a self-contained complete unit.

The cut gears are of semi-steel, having involute teeth of the proper pitch for the rated load and speed. The motor pinion is rawhide, thus insuring smooth, quiet running and minimum of wear. Gear guards made of heavy steel bands are furnished, covering both gears and pinions. The clutch and brake levers are mounted in a rack convenient for the operator. A foot brake is also provided.

TABLE OF SIZES, ETC.

Hoist Number	HOISTING DUTY		ENGINE	DRUM			Size of Rope Inches	Approx. Floor Space Inches	Weight Pounds	Telegraphic Cipher
	Load or Rope Pull, Pounds	Rope Speed, Feet Per Minute	Horse Power	Diameter, Inches	Length Between Flanges, Inches	Feet of Rope Drum Will Hold				
80½	2500	225	20	16	22	1200	⅝	55x67	4700	Sanged
81½	3500	225	30	26	24	2500	⅝	65x77	7200	Saplessed

NOTE:—

Each Hoist is furnished with Water Cooling Tank, Fuel Tank and Full Equipment of accessories necessary for successful operation.

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The Denver Engineering Works Co.

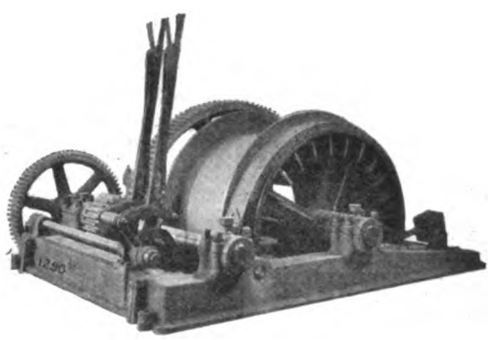
Suite 333 Cooper Bldg., DENVER, COLO.

ENGINEERS — MANUFACTURERS

Hoisting, Crushing and Concentrating Machinery

Products

Electric Hoists, Rod and Ball Mills, Concentrating Machinery, Jaw Crushers, Rolls, Ore Samplers, Mine Timber Framing Machines, Mine Cages and Skips, Sample Grinders, Gears, Pulsator Classifiers and Jigs, Flotation Machines.



Dewco Electric Hoist

Electric Hoists

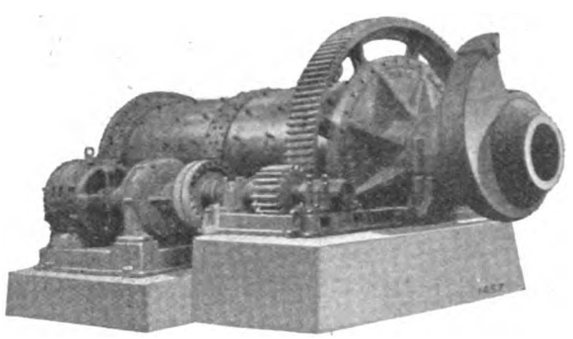
For metal, coal mining and quarry operations.

From small sectionalized to large heavy duty types single, double or triple drums.

Vertical or incline shaft.

Winding engines for continuous haulage.

27 years of successful operation.



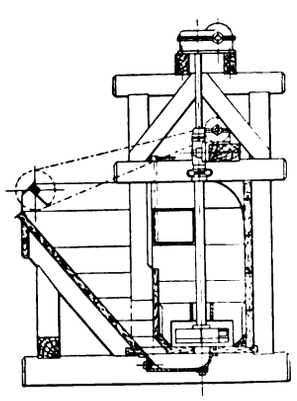
Dewco Rod Mill

Rod and Ball Mills

For wet or dry crushing on metallic or non-metallic materials.

Reduce crusher product to table or flotation pulp in one operation.

Simple design, rugged construction, continuous service, minimum adjustment.



Greenawalt Flotation Machine

Concentrating Machinery

Greenawalt Flotation Machine—Thorough agitation, high mineral recovery. Arranged for electric motor or belt drive.

Richards Pulsator Classifiers—For classification of table pulps.

Richards Pulsator Jigs of large capacity for high grade concentrate and for recovering mineral in placer operations.

Associated for more than 25 years in the development of mining and metallurgical operations, we are prepared to design efficient ore treatment systems and furnish thoroughly built machinery equipment under the supervision of competent engineers and builders.

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JOSHUA HENDY IRON WORKS

ESTABLISHED 1856

General Office

61-75 Fremont Street, SAN FRANCISCO, CALIFORNIA

Works—Sunnyvale, Santa Clara Co., California

Manufacturers of

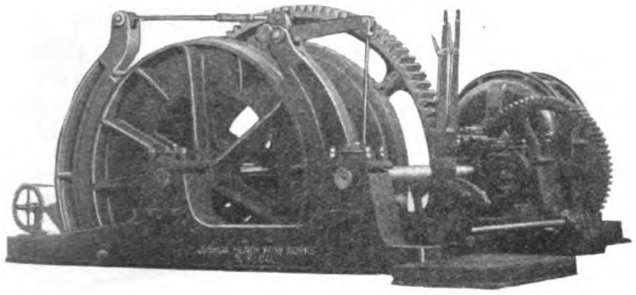
Mining Machinery

Products

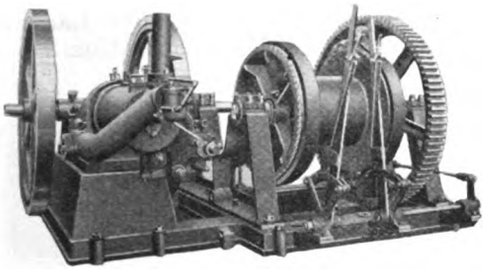
Mine Hoists operated by Steam, Electricity, Air or Water Power.

Industrial Hoists; Derricks; Winches; Cableways; Mine Cages; Skips; Buckets; Safety Crossheads; Sheaves, etc.

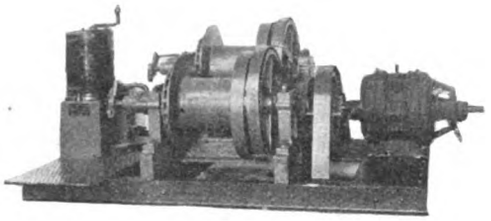
For other products see pages 360, 528, 529, 630 and 631.



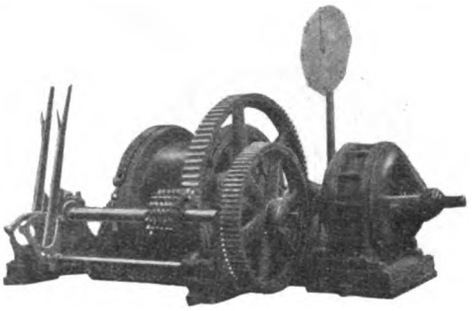
Heavy Duty Single Drum Type, particularly designed to meet the severest requirements, made in sizes from 50 to 350 H. P.



Oil Engine Hoists that will burn Gasoline, Kerosene, Distillate or Stove Oil. Made in sizes from 5 H. P. to 100 H. P.



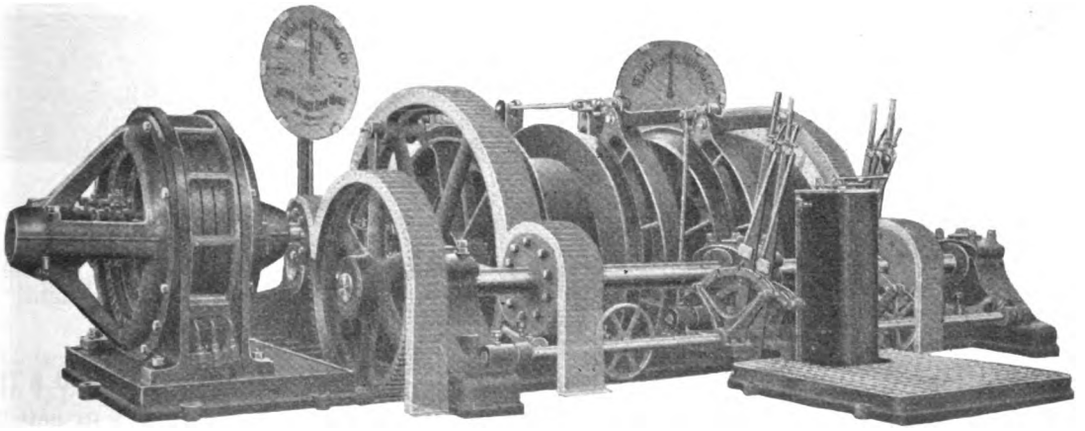
Special Double and Triple Drum Hoists either direct-connected to Electric Motor or Gas Engine for Contractors, Quarries, Lumber Yards, etc.



Single and Double Drum Hoists from 15 to 100 H. P., fitted with band brakes, band friction clutches, rawhide pinions, cut gears for use in small mines and prospects.

Special Bicycle Type Sheaves with wrought iron spokes built in all sizes for any requirements.

Cages and Skips designed to meet the conditions of any shaft and built to comply with all the safety laws.



Standard Type Double Drum Mine Hoist made in sizes from 50 to 350 H. P. and operating either with double reduction cut gears and rawhide pinions, or single reduction with Herringbone gears.

Heavy post brakes, band friction clutches. Simple, Rugged, Efficient.

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LAKE SHORE ENGINE WORKS

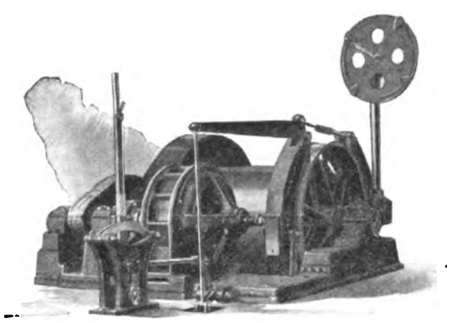
MARQUETTE, MICHIGAN

Designers and Manufacturers of

Electric, Steam and Air Hoists for Hoisting, Haulage, Scraping

Products

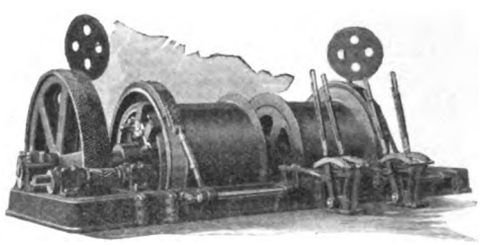
Situated in the heart of the Lake Superior iron and copper mining district, and specializing for thirty years in the manufacture of mining equipment, we have developed a complete line of mine hoists, cars, skips, cages, buckets, car wheels, sheaves, drills, mechanical loaders, scraper hoists, etc. It is impossible to show in these pages the wide range of designs we have perfected. Our engineering organization is at the disposal of prospective purchasers without obligation. We have catalogs of our various lines which we will be pleased to supply upon application. For other products, see Pages 363 and 415.



Single Drum Electric Hoist

Single drum electric hoist with double reduction gearing—post brakes—no clutch. For development and underground service.

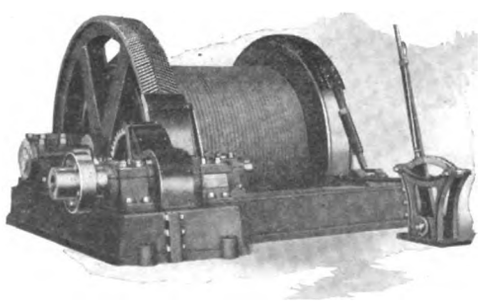
Built in 3 ft., 4 ft. and 5 ft. sizes.



Double Drum Electric Hoist

Double drum electric hoist with single reduction Wuest gearing—band brakes and Lane friction clutches—arranged for hand operation.

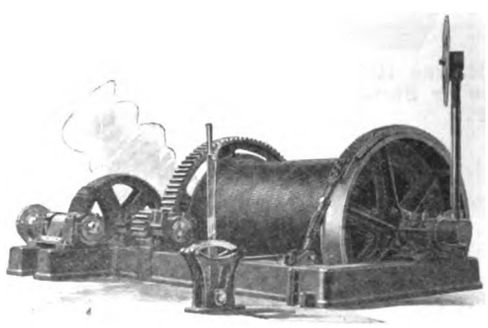
Built in 4 ft., 5 ft., 6 ft. and 8 ft. sizes.



Single Drum Electric Hoist

Single drum electric hoist with double reduction Wuest gearing—band brake—no clutch.

Built in 4 ft., 5 ft., 6 ft., 7 ft. and 8 ft. sizes.



Single Drum Electric Hoist

Single drum electric hoist with double reduction (spur and herringbone) gearing—band brake—no clutch.

Built in 4 ft., 5 ft., 6 ft., 7 ft. and 8 ft. sizes.

OUR EXPERIENCE—THIRTY YEARS IN THE LAKE SUPERIOR MINING DISTRICT

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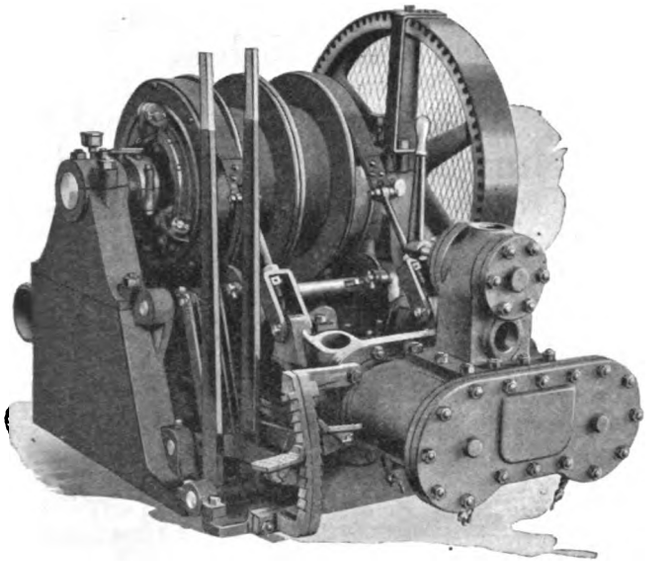
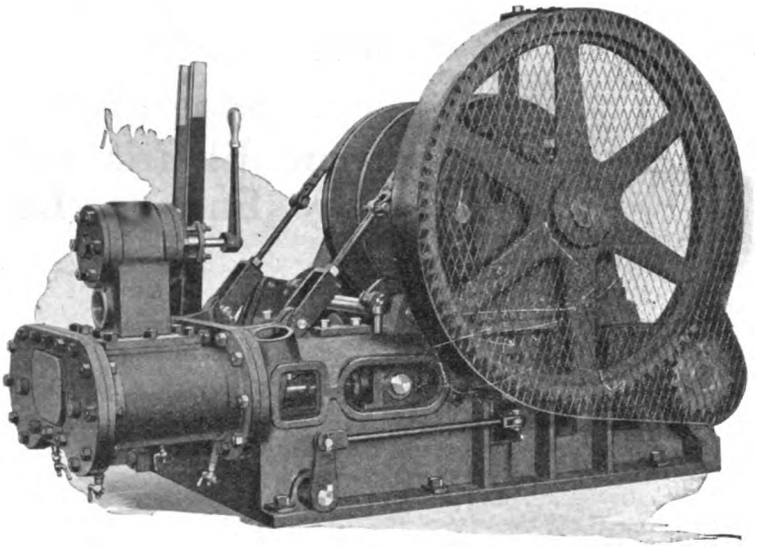
Air and Electric Scraper Hoists



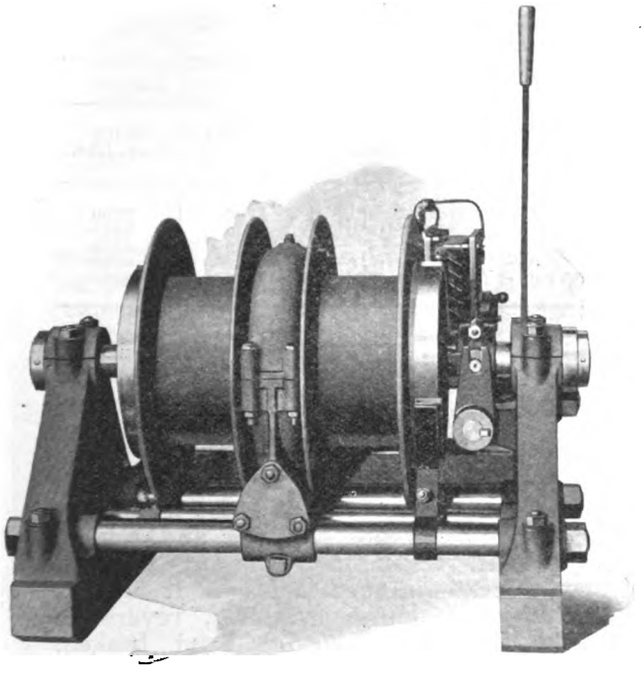


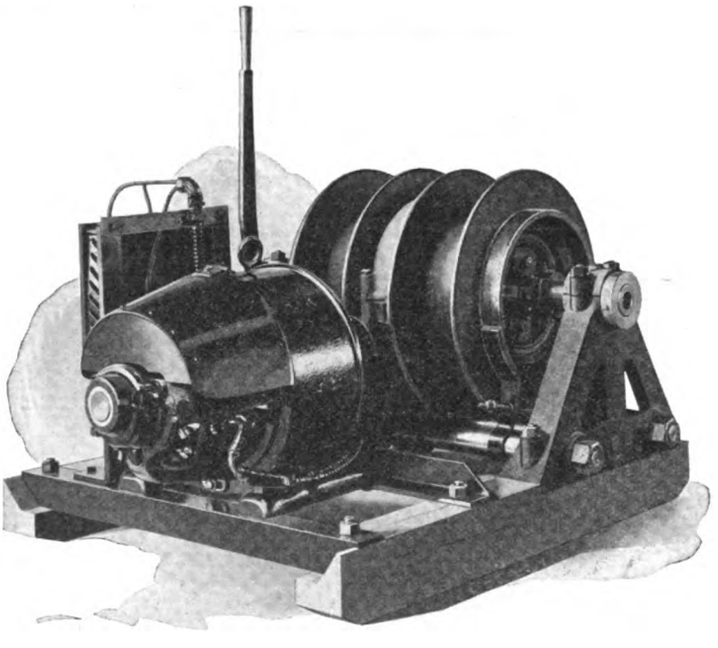
General Description

6 in. x 9 in. Double Cylinders with reversing throttle.
Two Drums 12 in. diameter with flanges 24 in. high.
Multiple Disc Friction Clutches.
Rope Spool on crank shaft.
Capacity drums 400 ft. ½ in. rope.
Rope speed 200 ft. per minute.
Capacity 3,500 lbs. rope pull at 80 lbs. air pressure.

Overall Dimensions

Width 3 ft. 6 in. Height 3 ft. 6 in. Length 5 ft. 3 in. Weight 3,500 lbs.





General Description

7½ H. P. motor.
Two Drums 12 in. diameter by 5½ in. face.
Expanding Shoe Friction Clutches.
Drum capacity 275 ft. ½ in. rope.
Rope speed 125 ft. per minute.
Capacity 2,000 lbs. rope pull.

Overall Dimensions

3 ft. 4½ in. wide; 4 ft. 2 in. long; 2 ft. 4 in. high. Total weight 1,400 pounds.

The two types of hoists shown on this page are designed especially for operating scraper loaders now in popular use in the mines. They are designed especially for this service and have given excellent results wherever they have been used. Quick acting and powerful clutches, portability and compactness feature these machines. We have much additional data which we will supply on application.

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J. S. MUNDY HOISTING ENGINE CO.

ESTABLISHED 1869

Office and Works: 722-744 Frelinghuysen Ave., NEWARK, N. J.

Engineers and Manufacturers of

The "Mundy" Steam, Electric and Gasoline Mine Hoisting and Haulage Engines; Derricks; Cableways

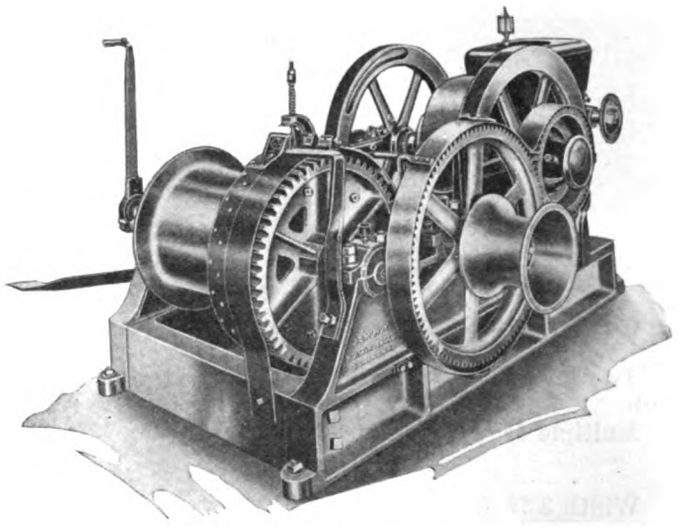
Gasoline Mine Hoist

Constructed with Fairbanks Morse Type Z Gas Engine with gear-driven magneto.

Easily transported and quickly set up in working position.

This mine hoist was developed for prospecting work, and was designed with the view of it being transported frequently. The following table gives the ratings of the standard sizes.

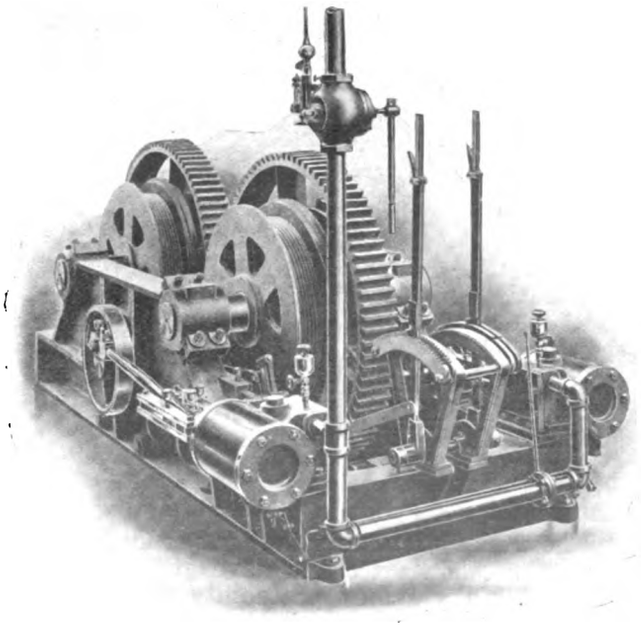
We design special gasoline mine hoists to suit individual requirements.



Gasoline Mine Hoist

GASOLINE MINE HOIST

H. P.	R. P. M.	Fly Wheel Inches	Drums		Capacity		Bed Plate		Shipping Weight	
			Diam. Inches	Length Inches	Speed Ft. per Minute	Load Pounds	Length Overall	Width Overall	Without Eng. Lbs.	With Eng. Lbs.
3	475	22	16	16	150	500	5'-1"	2'-9"	2200	2500
6	450	28	16	16	150	1000	5'-2"	3'-0"	2300	2800
10	350	41	16	20	150	1750	6'-0"	3'-4"	2400	4250
15	350	44	16	20	150	2500	6'-7"	3'-8"	2500	4800
20	300	54	20	22	150	3000	7'-9"	3'-9"	3500	6500



Cableway Haulage Engine

This engine is designed for cableway haulage, underground haulage and mines, for inclines, or in fact for any purpose where an endless rope is used. It is constructed with double cylinders, reversible link motion and powerful band brakes, Raybestos lined. The grooved wheels for the rope are made of semi-steel to withstand heavy duty, and are bolted to the gears so that they can be replaced.

WRITE FOR MINE HOIST BULLETIN

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OTTUMWA IRON WORKS

OTTUMWA, IOWA, U. S. A.

ESTABLISHED 1867 INCORPORATED 1903

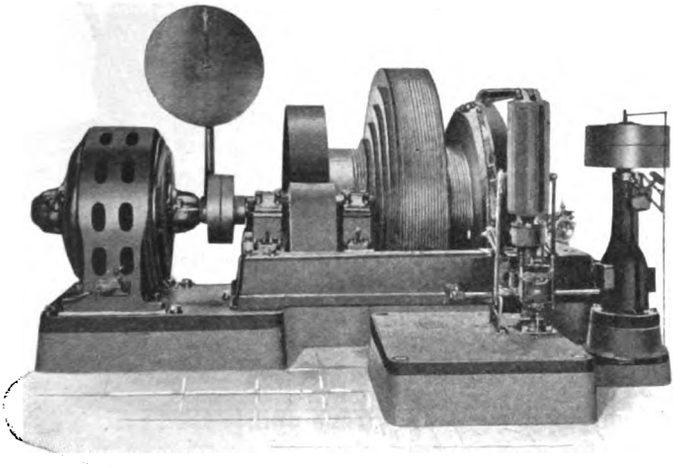
Electric and Steam Hoists, Mine Cars, Roller Bearing Trucks, Etc.

Products

"Ottumwa" Cylindro-Conical Drum Electric Hoists.
"Ottumwa" Standard Cylindrical Drum Electric Hoists.
"Ottumwa" Steam Hoists.
"Ottumwa" Patent Roller Bearing Trucks, Mine Cars, Sheaves and Rollers.

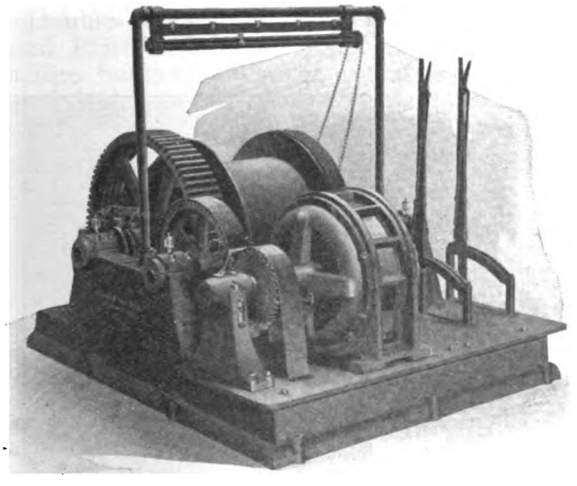
Hoists

The Ottumwa Iron Works build Hoists that are reliable and which meet the specific requirements of



customers. The long experience of their Engineering Department is at all times at the service of customers.

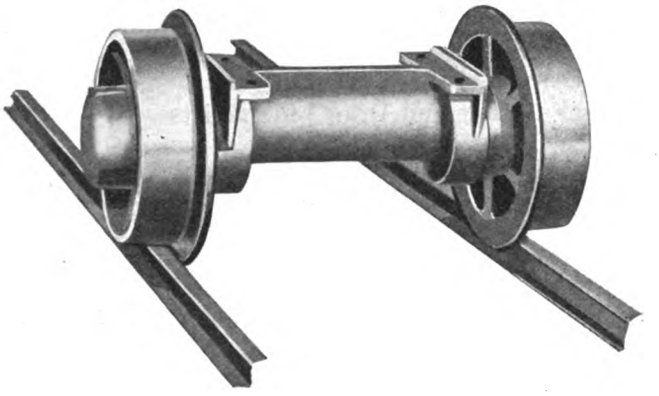
Embodied in the Ottumwa Hoists are the latest improvements. The Ottumwa Iron Works have in-



vented, perfected and patented a number of devices for Electric hoists which have proven wonderfully effective. The Ottumwa Cylindro-Conical Drum Hoists have saved as much as 25% in power consumption.

Trucks

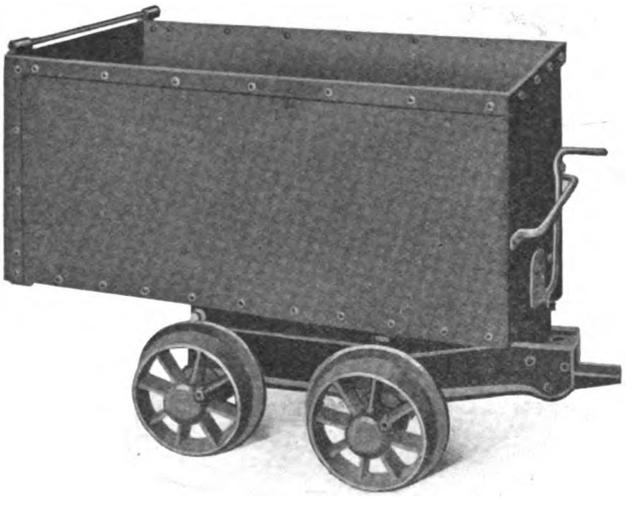
In the manufacture of the "Ottumwa" Patent Roller Bearing Trucks the Ottumwa Iron Works



produces not only a high grade wheel, but also a mechanically correct Roller Bearing which is guaranteed to give satisfactory service. The wheels are amply chilled to insure long wear. Write for Bulletin No. 210.

Mine Cars

The Mine Cars manufactured by the Ottumwa Iron Works are built for service. Only the best grade material for the purpose is used



in their construction. They are equipped with "Ottumwa" Patent Roller Bearing Trucks. Write for prices, giving the following information:

Wheel diameter .....
Diameter of axle .....
Track gauge .....
Wheel base .....
Capacity of car.....Lbs.

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The Pneumelectric Corporation

Pneumelectric TRADE MARK

SYRACUSE, N. Y.

Pneumelectric TRADE MARK

Hoists, Pumps and Rock Drills

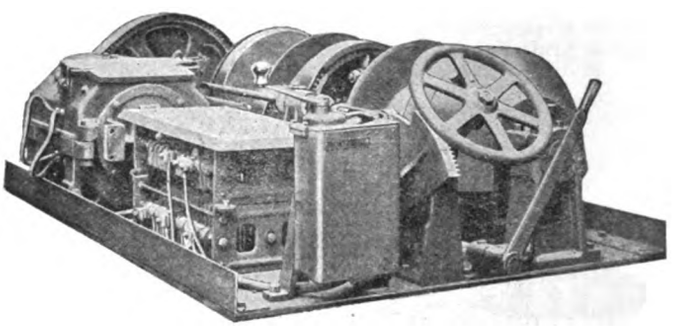
Products

Hoists—Scraper Loader and Drag Line; Small Electric and Small Single Drum; Drills—Electric Rock and Electric Plugger; Electric Mine Pumps.

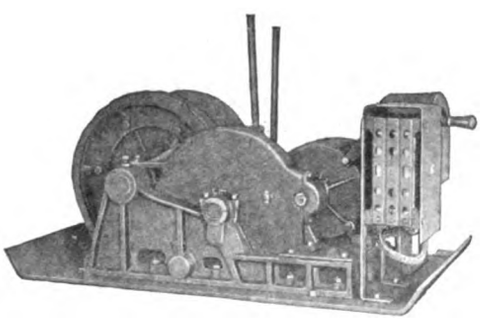
Scraper Loader and Drag Line Hoists

1500 to 4000 pounds rope pull.
Friction drive.
Internal expanding band clutch.
Band brake.
Machine cut steel gears.
Steel plate base.
Motor either Alternating Current or Direct Current.
Dimensions—Height, 27 inches; length, 65 inches; width, 94 inches.

Also made in single drum for general hoisting purposes.



Scraper Loader and Drag Line Hoist

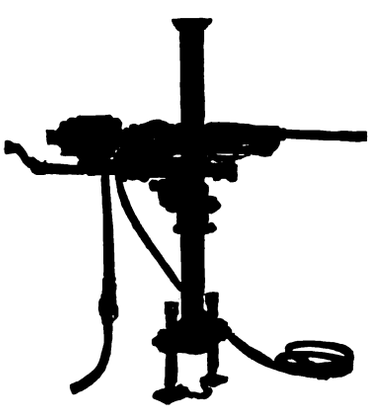


Small Single Drum Hoist

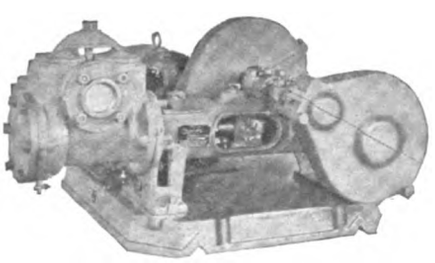
Small Electric Hoists for General Service

Capacity—1000 to 2000 pounds rope pull.
Positive drive through jaw clutch.
All gears machine cut.
Electrical equipment either Alternating Current or Direct Current with resistance for running speed control.
Motor capacity 5 to 15 H. P.
Dimensions—Height, 30 inches; length, 52 inches; width, 28 inches.

Also made in double drum.



Electric Rock Drill



60-Gallon Capacity Electric Mine Pump

Electric Plugger for Drilling "Up" Holes

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THOMAS ELEVATOR COMPANY

20 South Hoyne Avenue, CHICAGO, ILL.

Manufacturers of

ELECTRIC MINE HOISTS

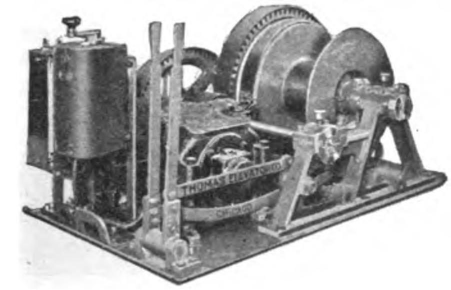
Products

Electric Hoists for use in mines, tunnels and quarries. For service in hoisting from shafts, inclined car hauls, gathering cars and moving Scraper Loaders.

Built with Single Drum having Band Friction; also as a direct connected unit.

Thomas Electric Gathering Hoist

Designed for much heavier line pull than the ordinary gathering hoist and is fitted with our pat-



Thomas Gathering Hoist.

ented Cone Friction Clutch, which eliminates time lost in shifting pinions in and out of engagement on other hoists.

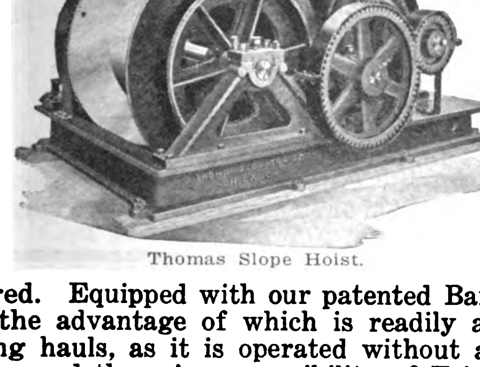
Over-all dimensions: Width 32″; Length 60″; Height 29″.

TABLE OF SPEEDS AND CAPACITIES
For 220 Volt Direct Current

Catalog Number	H. P. Motor	Line Pull in Pounds	Speed in Feet per Minute	Approx. Shipping Weight	Electrical Control Apparatus
2401	5	900	150	1680	Starting Switch only.
2402	5	900	150	1680	Variable Speed Control.
2403	7½	1400	150	1850	Starting Switch only.
2404	7½	1400	150	1850	Variable Speed Control.
2405	10	1500	175	1850	Starting Switch only.
2406	10	1500	175	1850	Variable Speed Control.

Thomas Slope Hoist

A Double-Reduction Single-Drum Hoist of the Band Friction type, designed for shaft sinking, incline haulage and other classes of service where a large drum and ample cable capacity are



Thomas Slope Hoist.

required. Equipped with our patented Band Friction, the advantage of which is readily apparent on long hauls, as it is operated without a thrust bearing and there is no possibility of Friction becoming hot. When this hoist is ordered with machine cut grooves in drum, friction clutch can be locked into engagement at any time and hoist used as a Direct-Connected outfit for operating cages or cars in balance.

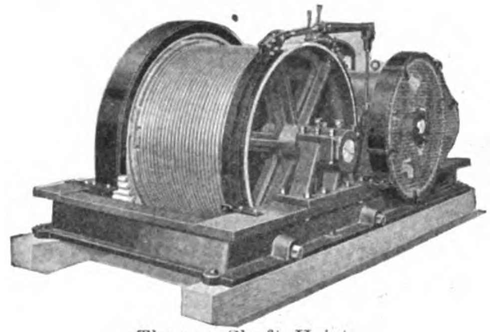
SLOPE HOIST DATA TABLE
Speeds and Capacities Based on Application to Intermittent Service and Can Be Varied to Meet Particular Requirements

For 220-550 Volt	Catalog No.	H. P. of Motor	Drum Dimensions			Hoisting Duty		Bedplate Dimensions		Approx. Shipping Weight Lbs.
			Dia. In.	Face In.	Fl'gs In.	Load Single Line	Speed Ft. per min.	Width In.	Length In.	
Direct Current	K15D	50	18	22	36	5000	300	57	84	7000
	P12D	100	26	25¾	46	7500	350	57¼	95½	9200
	P629D	150	42	30	58	10000	450	70⅜	117	12800
	P652D	250	54	44	76	12000	600	89¾	168	25000

For 3-Phase 60-Cycle 220-440 Volt	Catalog No.	H. P. of Motor	Drum Dimensions			Hoisting Duty		Bedplate Dimensions		Approx. Shipping Weight Lbs.
			Dia. In.	Face In.	Fl'gs In.	Single Line Load	Speed Ft. per min.	Width In.	Length In.	
Alternating Current	K15A	55	18	22	36	5000	300	51	84	7100
	P12A	75	26	25¾	46	7500	290	57¼	95½	8950
	P12B	90	26	25¾	46	7500	325	57¼	95½	9100
	P629A	150	42	30	58	10000	450	70⅜	117	13000
	P652A	250	54	44	76	12000	600	89¾	168	25000

Thomas Shaft Hoist

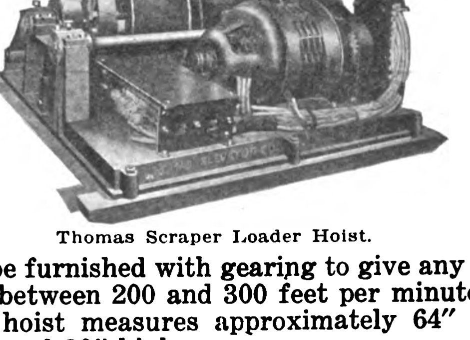
For operating cars or cages in counterbalance on a vertical lift or slope. Drum is machine scored and arranged to alternately wind and unwind a given amount of a certain size cable. Motor is reversible.



Thomas Shaft Hoist.

Scraper Loader Hoist

Designed especially for operating Scraper Loaders. Has normal line pull of 2,000 lbs. or a maximum line pull of 3,500 lbs. on a single line.



Thomas Scraper Loader Hoist.

Can be furnished with gearing to give any speed ranging between 200 and 300 feet per minute.

This hoist measures approximately 64″ wide; 64″ long and 30″ high.

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THE VULCAN IRON WORKS CO.

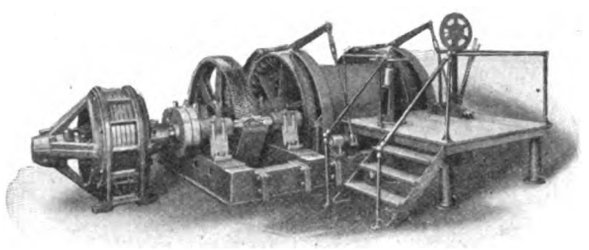
DENVER, COLORADO

Designers and Manufacturers of

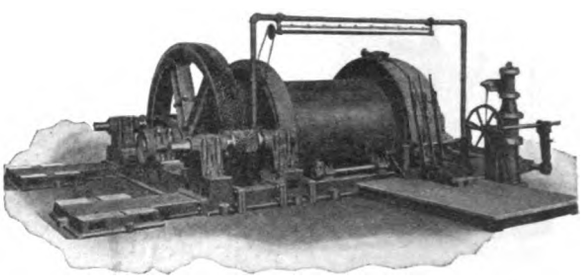
Electric and Steam Hoists
Skips, Cages, Sheaves and Ore Cars

Products

VULCAN-DENVER Electric and Steam Hoists and Haulage Engines—Single and Double Reduction and Direct Connected Types, made in 38 standard sizes. Gravity Lowering Drums.
Skips—Self-Dumping and Bottom Discharge. Cages—Platform and Self Dumping.
Sheaves—Steel Spoke and Solid. Cars—Side and End Dumping.
Gears—Spur, Helical and Herringbone.



Single Reduction Electric Hoist—20,000 Lb. Rope Pull



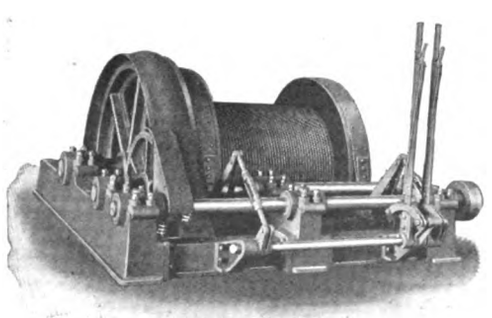
Single Reduction Electric Hoist—Two Motors, Power Operated Brakes

Skips

In many styles for vertical or inclined shafts and in combination with cages. Carefully reinforced and riveted to withstand hard service.

Cages

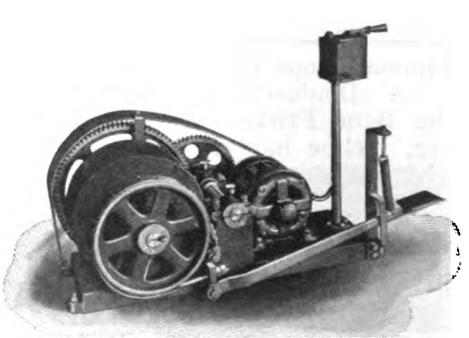
Large safety factors are used in the design of our cages. They are unusually rigid in construction and have simple positive safety gear. Automatic landing chairs if desired.



Double Reduction Electric Hoist with Herringbone Gears

Hoists

All hoist gears are accurately cut on the most modern gear cutting machinery. Post or band brakes, plate or band clutches are used according to conditions, and are hand or power operated. Materials used throughout are checked in our physical testing laboratory.



Portable Room Hoist

General

Thirty years of engineering and manufacturing experience in direct contact with the varied mining conditions of the West is incorporated into the designs of Vulcan-Denver Hoists and Mine Equipment. Our engineering department is always at your service for any co-operation or suggestion that you may desire.

VULCAN-DENVER Mine Equipment

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The Wellman-Seaver-Morgan Company

CLEVELAND, OHIO

BRANCH OFFICES AND AGENCIES

Akron Wilkes-Barre New York Birmingham
San Francisco London Mexico City Paris

Products

Electric and Steam Hoists and Haulage Machines; Cages; Skips; Sheaves; Head Frames; Safety Detaching Hooks; Incline Machines; Rotating Car Tipples; Ore & Coal Handling Machinery; Coke Oven Machinery; Hydraulic Turbines; Gas Producers; Special Cranes; Port and Terminal Equipment.

These various lines of manufacture are handled by separate departments, each department having its own staff of engineers especially trained for this particular class of work.

Standardization

Special attention has been given to standardization of the smaller size hoists which increases the efficiency of our own work and at the same time conserves the best interests of our customers.

Our catalogue of standard hoists, No. 58, gives all information regarding loads, rope speeds and principal dimensions and immediately indicates to the customer the proper size machine to meet his requirements.

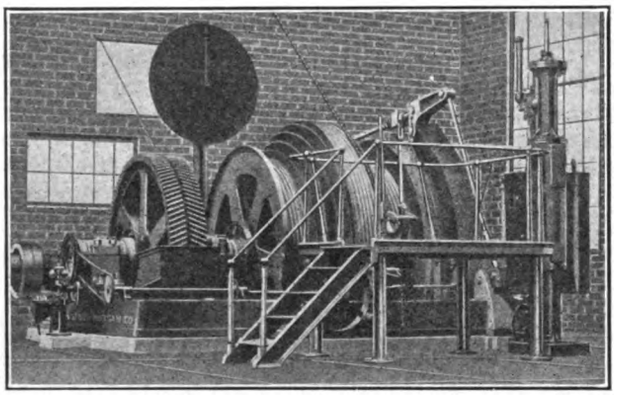
Wellman-Seaver-Morgan Products Speak For Themselves

Our experience during the past fifty years in the manufacture of mining machinery places us in position to properly solve the various engineering problems and build the type of machine best suited to the various requirements.

We have built electric hoists in sizes ranging from 3 to 1800 H. P. These hoists are faithfully performing their duty in the principal coal, iron, silver, gold and copper districts throughout the United States and foreign countries.

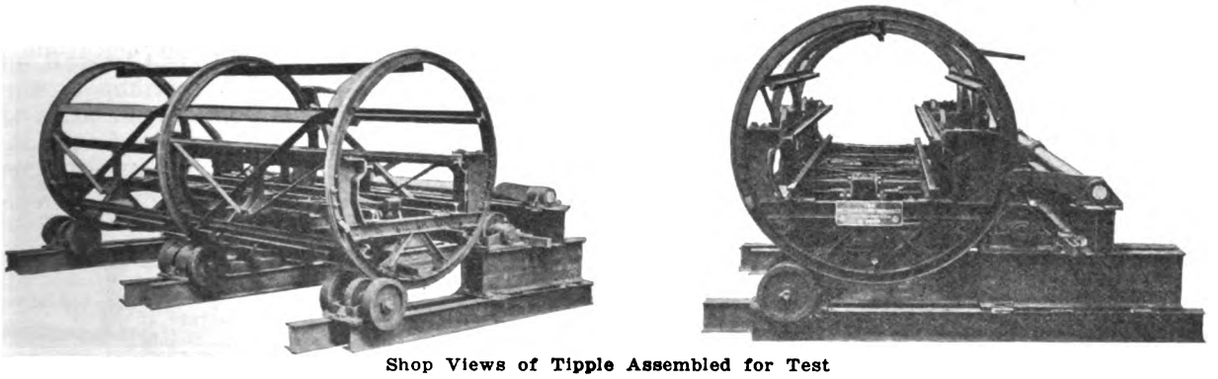
Our installations are found throughout the principal mining districts of the world.

We invite inquiries on both standard and special propositions and will be pleased to co-operate with the customer in every way possible.



Double Conical Drum Hoist. Capacity 1,000 Tons Coal Per Hour. 600 H. P. D. C. Motor.

THE W-S-M ROLLSRIGHT CAR TIPPLE



Shop Views of Tipple Assembled for Test

This is a sturdily designed machine consisting of simple sections, principally tee rails and angle bracing, which operates solely by gravity. No outside source of power is required. No skilled labor needed. Cost of operation is confined to the lubricant only. The principle of operation is extremely simple. The center of gravity in the tube is offset from the center of rotation. This overturns and dumps one or more cars by gravity. Fly wheels store energy and bring the tube back to original position, ready to receive more cars. It will handle any coarse or dry fine material. Installations in successful operation for three years. Send for Bulletin No. 68.

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CAR-DUMPER & EQUIPMENT CO.

1216-1222 E. 75th St., (Grand Crossing), CHICAGO, ILL.

Pittsburgh San Francisco Seattle Los Angeles Marquette, Mich.

Equipment for Handling and Unloading Cars

Products

ROTARY CAR-DUMPERS FOR MINE CARS (Gravity, Electric or Pneumatic Drive).

ROTARY CAR-DUMPERS FOR STANDARD GAUGE RAILROAD CARS.

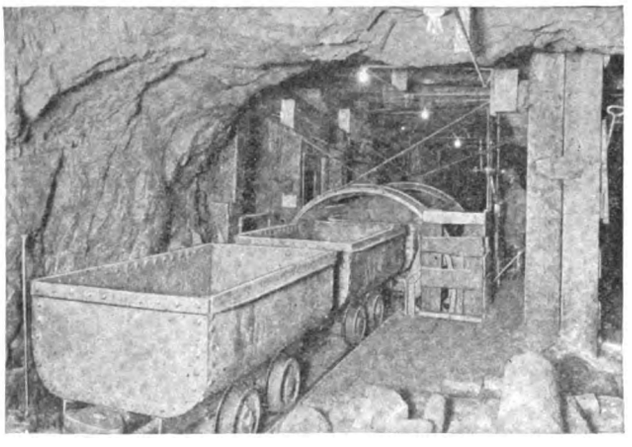
"SOLIDCAR" SELF-DUMPING CAGES.

MECHANICAL SPRAGGERS.

TRIP FEEDING AND CAR CAGING EQUIPMENT.

Applications of Rotary Car-Dumpers

The many installations of Rotary Car-Dumpers and Car Handling Equipment have proved that they reduce the first cost and the operating cost, and increase the capacity, at Mines, Smelters, Quarries, etc.



One-Man Shaft Station

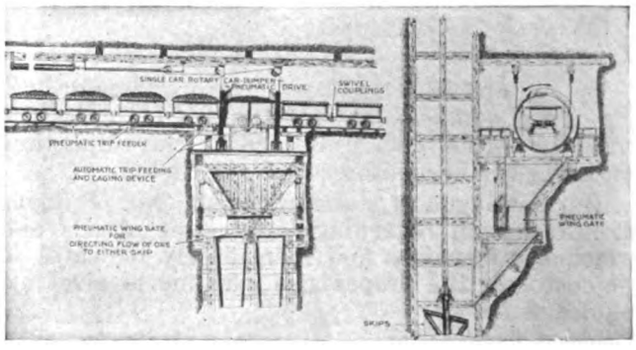
Automatic Trip Feeder and Rotary Car-Dumper

Handles trips and dumps cars without uncoupling cars from trip. Locomotive can stay on trip if desired.

One Man: Handles and dumps trips of cars.
Samples ore.
Signals hoist.

A Rotary Car-Dumper enables the use of a solid-body car—no gates or tipping devices; just a simple solid body, mounted firmly on the truck. Such solid-body cars are inexpensive, and so sturdy that there is practically no expense for maintenance. When compared to saddle-back or dump cars the saving in first cost will more than pay for the Rotary Car-Dumper. Any type of car, however, can be handled in the Rotary Car-Dumper, and upkeep can usually be reduced by sealing up and reinforcing any gates or tipping equipment as the cars are shopped.

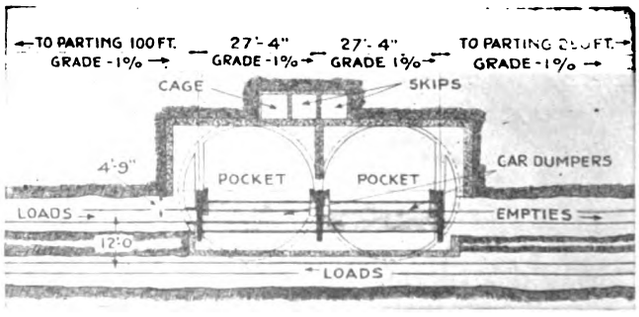
Rotary Car-Dumpers save labor. Installations usually are so arranged that one man can dump the cars, without uncoupling the trip, while Car Handling Equipment feeds the trip through the Rotary Car-Dumper and spots the cars in dumping position. Often the trip-rider or brakeman can unload the cars, one or more at a time, without even uncoupling the locomotive from the trip.



One-Car Rotary Car-Dumper at Shaft Station

Typical design for dumping directly to skips in two-compartment shaft. Storage pockets and loading gates can be used if desired. Capacity, from 30 to 240 cars per hour.

Rotary Car-Dumpers speed up the production. Some smaller sizes operate seven times per minute. One or more cars can be dumped at a time. Rotary Car-Dumpers of one, two and three car capacities are quite common, and some dump whole trips, overturning 20 to 30 cars at each operation. The



Rotary Car-Dumper Over Storage Pocket

Usually made long enough to cover pocket, dumping one or more cars. Drawing shows six-car Rotary Car-Dumper designed to operate without uncoupling cars. Operated by trip-rider or skip attendant. Cars spotted automatically in dumping position. Trips moved by locomotive, by mechanical feeder, or by gravity.

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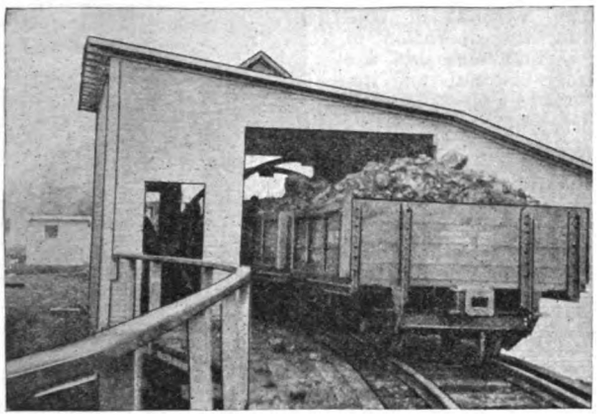
cars are completely overturned, dumping them thoroughly as well as rapidly. This releases the trips of empty cars quickly, without the usual delays inseparable from the use of saddle-back or dump cars.

Underground Installations

Rotary Car-Dumpers are used extensively at shaft stations for unloading cars to skips or to storage pockets. They are usually built to unload one or two cars at a time, and to operate from one to four times per minute. Frequently the Rotary Car-Dumper is made long enough to handle as many cars as can stand over the storage pocket.

Nearly always one man can operate the Rotary Car-Dumper and also do the other work at the shaft station, such as loading the skips and sampling the ore. Often the locomotive remains coupled to the trip while the trip-rider dumps the cars without uncoupling them. Then they are ready for immediate return to the mine.

This company publishes a very interesting bulletin, giving engineering data and drawings of a number of typical shaft station installations. Sent on request.



Rotary Car-Dumper Unloading Solid-Body Quarry Cars

Cars are unloaded one or more at a time without uncoupling locomotive from trip. Brakeman operates Car-Dumper and returns with empty trip to shovel. Trip is unloaded in from one to two minutes. If desired, locomotive can leave trip, which then can be handled and dumped by one man.

Surface Installations

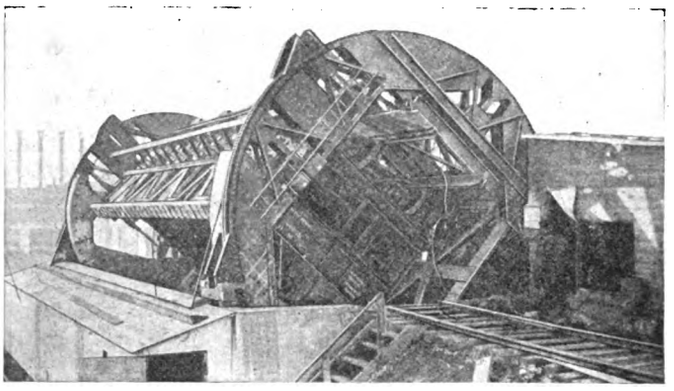
The Rotary Car-Dumper is especially desirable at mines or quarries where trips of cars are delivered to a common dumping point by either locomotives or rope haulage. It can be mounted over the crusher, storage bin, loading chute, or other disposal. In general, the method of application is similar to that for underground use. It will handle any type of car, for all track gauges.

In open pits the solid-body car—a simple box mounted firmly on the truck—stands up well in steam shovel loading and similar rough handling, with practically no upkeep expense. It weighs one-third less, is twice as strong, and costs only half as much as the contractor type of dump car. The saving in cost of ten cars will more than pay for the Rotary Car-Dumper.

A special bulletin giving engineering data and drawings of installations at quarries, crushing plants and stripping operations is available on request.

For Standard Gauge Railroad Cars

Any industry which unloads more than ten or twelve railroad cars per day can do the work more cheaply and rapidly in a Rotary Car-Dumper. It will receive all types of open-top cars and unload them without the slightest injury — gondolas or hoppers of all capacities.



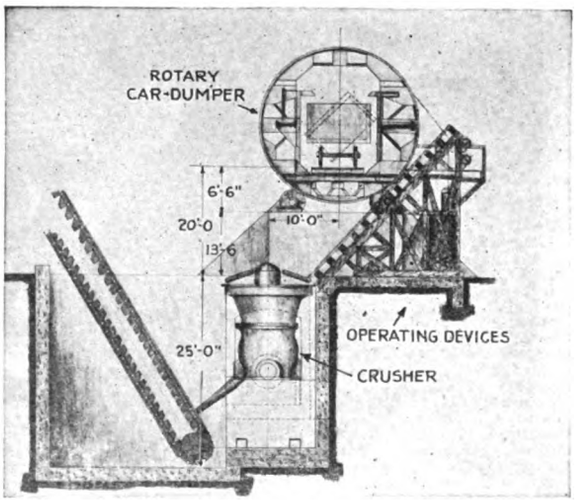
Rotary Car-Dumper for Railroad Cars

Installed over Track Hopper for rapid unloading of cars. Material removed from Hopper to Plant or Stock Pile by Conveyor or Crane.
One common laborer can handle cars and operate Rotary Car-Dumper.

The Rotary Car-Dumper can be operated by a common laborer, and one man can handle and unload 10 cars per hour. The capacity of the equipment is up to 30 cars per hour.

The installation complete costs no more than a good locomotive crane, while its speed is much greater and its operation much less expensive.

Power consumption, 2 kilowatt-hours per car unloaded.



A Typical Surface Installation

One arrangement of Rotary Car-Dumper, showing unloading of standard gauge railroad car direct to crusher. Other arrangements to suit any local conditions. Cars of any types, on tracks of narrow or standard gauge.

A special bulletin giving engineering data and drawings of installations at crushing plants, power houses, stock piles and mills is available on request.

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DURO METAL PRODUCTS CO.

360 East Grand Avenue, CHICAGO

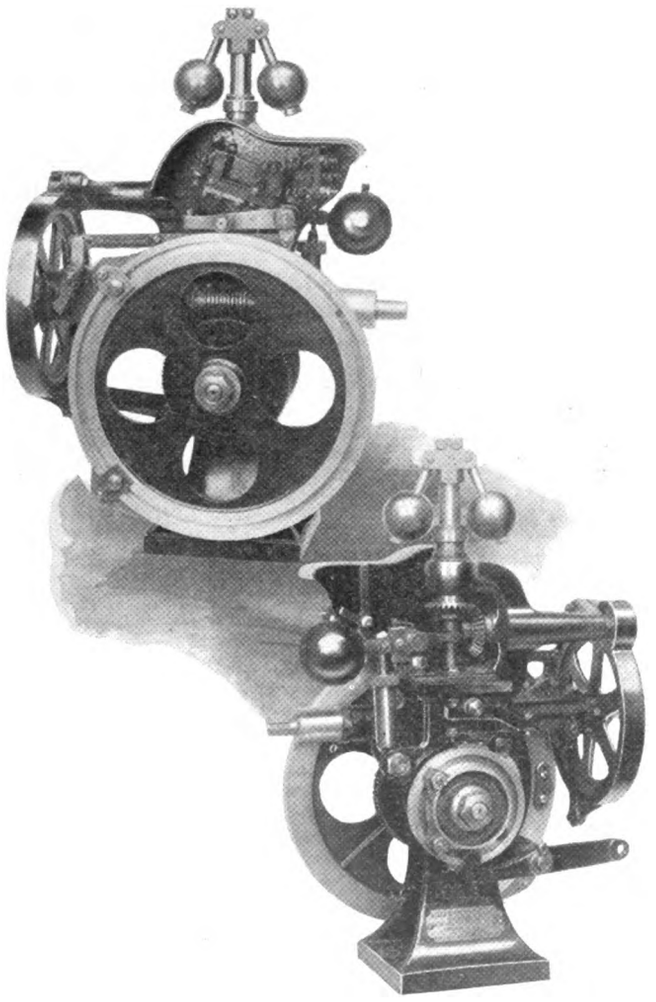
Manufacturers of

The Lilly Hoist Controller and Other High Grade Machinery

The Lilly Hoist Controller

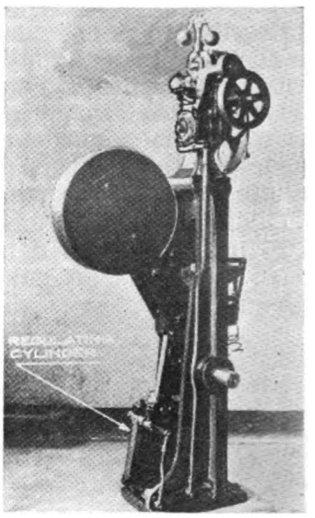
The Lilly Hoist Controller is a mechanical and electrical safety device for controlling mine hoists, and keeping their speed and travel within predetermined limits. It is also a monitor to guide and warn the engineer, and assist him in the safe operation of the hoist, allowing him to operate as desired within the limits of safety, and only taking the control from him and performing the necessary operation for safety in case of failure or miscalculation on his part.

The Lilly Controller is applicable to nearly all types and sizes of steam, air, and electric hoists, and may be installed on hoists in use, without delaying their operation. For new hoists it is desirable to have the hoist builder supply the Lilly Controller installed on the hoist.



The Lilly Controller is not a competitor on a price basis, for devices that simply cut off the power and slam the brakes on, but is designed to fully meet the requirements of a complete high-grade device depending for safety on the only reliable agent—GRAVITY. For normal operation of hoist, weights or contactors are magnetically held, subject to instantaneous release by the controller or by current failure.

It operates smoothly, and applies the brakes gently but firmly for all high speed points. Toward the end of travel, the brake action is quickened until at the extreme end it is instantaneous. This gives the necessary quickness of action where it is required, yet protects against dangerous shock for operating at high speed. This is vitally important, especially for large hoists.



Lilly Controller with standard equipment for small electric hoist, hand operated.

The methods of controlling the operation of the various elements are entirely original, and are protected by U. S. and foreign patents.

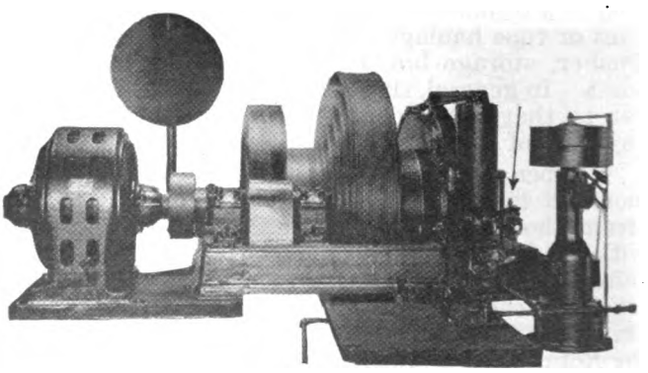
Where it is desired to handle men at a reduced speed, a "Man-safety Attachment" can be supplied, which prevents the man speed being exceeded, forces a stop at the man-landing, and shows lights at the shaft to prove that the man-safety is operating, as a check on the engineer.

The design, material, and construction of the Lilly Controller is the best that can be produced, and it should operate efficiently for the life of the hoist.

We require detailed information regarding contemplated installations, and will gladly send data sheets calling for necessary data to enable us to recommend the proper equipment and to quote price.

It is generally conceded that the Lilly Controller should be on all hoists handling men, and even where men are not handled, an overwind or runaway may result in loss of life among men whose duties make it necessary to work nearby.

The Lilly Controller has been adopted as the standard safety device by the leading hoist builders of America, and



Lilly Controller installed on 400 H. P. electric coal hoist. (Factory installation).

DO NOT BE SATISFIED WITH AN OBSOLETE TYPE OF SAFETY EQUIPMENT. THERE IS A LILLY CONTROLLER FOR YOU.

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the highest class of hoists is now equipped with it. It is also the standard for many of the largest and most progressive mining companies. It has been installed on some of the world's largest hoists and on some very small hoists. with entirely satisfactory results.

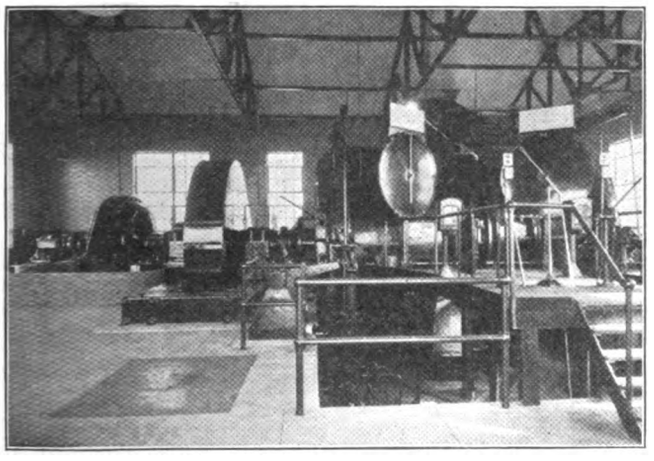
The following hoist manufacturers use the Lilly Controller, and nearly all of them have standardized on it.

Allis Chalmers Mfg. Company.....Milwaukee, Wis.
Denver Engineering Works Co., The.....Denver, Colo.
Diamond Machine Company.....Monongahela, Pa.
Hardie-Tynes Manufacturing Co.....Birmingham, Ala.
Lake Shore Engine Works.....Marquette, Mich.
Litchfield Foundry & Machine Co.....Litchfield, Ill.
National Iron Company.....Duluth, Minn.
Nordberg Manufacturing Company.....Milwaukee, Wis.
Ottumwa Iron Works.....Ottumwa, Iowa
Thomas Elevator Company.....Chicago, Ill.
Wellman-Seaver-Morgan Co.....Cleveland, Ohio

Other hoist manufacturers recommend the Lilly Controller, and use it where specified.

We solicit correspondence with all manufacturers of hoisting equipment, wherever located, and all engineers and others having to deal with hoists, should have their names on our mailing list, so that we can forward all information regarding new features or applications.

Our broad experience with hoists of various kinds working under a variety of conditions both on the surface and underground, together with our continual co-operation with the electrical companies, hoist manufacturers and engineers, and our contact with the Lilly Controller in the field, enables us to recommend the proper equipment to suit any conditions. We are glad to make recommendations, without any obligation whatever.



Lilly Controller double installation on 1800 H. P. electric hoist. (Factory installation).

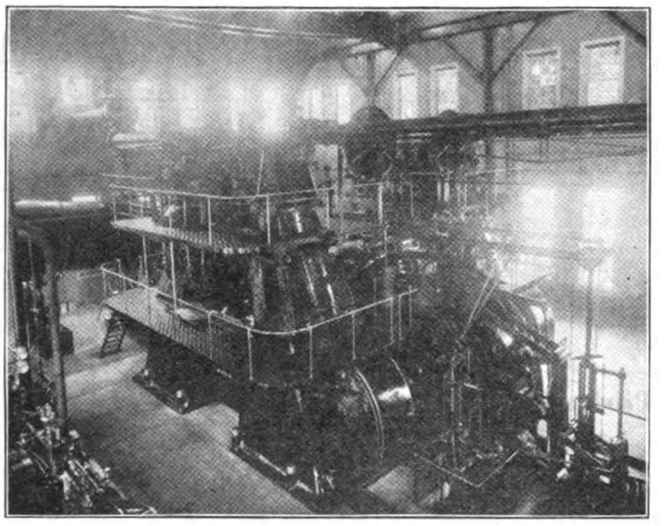
To facilitate the equipping of hoists in the field, and to assist us in rendering first class service to our customers in distant fields, the following representatives have been appointed.

Western States
The Denver Engineering Works Company, Denver, Colo.

Anthracite District of Pennsylvania
The Scranton Electrical Construction Company, Pottsville and Scranton, Pa.

South Africa
Edward Bateman, Johannesburg, South Africa

Accidents resulting from overwinds or runaways are expensive, usually costing more than a Lilly Controller installation, to say nothing of non-production while repairs are in progress, and when life is lost, the damage is irreparable. Can you afford to take chances with no protection, or even with obsolete equipment, when you can install Lilly Controllers and get the very best that engineering skill has been able to devise. Think of it when you go down the shaft, when you come up, or when the other fellow goes, and write us without delay.



Lilly Controllers are installed on this giant steam hoist, which stands 30 ft. high. The engineer was killed by a rope breaking, but a serious wreck was averted by the Lilly Controller stopping the hoist.

The following is a partial list of mining companies who have purchased Lilly Controllers either direct or through hoist builders.

Many of these companies have standardized on the Lilly Controller, and have a large number of them in use.

Alabama Fuel & Iron Company.....Birmingham, Ala.
American Coal Mining Company.....Bicknell, Ind.
American Lime & Stone Company.....Bellefonte, Pa.
Anaconda Copper Mining Company.....Butte, Mont.
Annapolis Lead Company.....Annapolis, Mo.
Buck Run Coal Company.....Minersville, Pa.
Burma Mines Corporation.....Burma, India
Calumet & Hecla Mining Company.....Calumet, Mich.
Calumet & Arizona Mining Company.....Warren, Ariz.
Cambria Steel Company.....Johnstown, Pa.
Carter Coal Company.....Coalwood, W. Va.
Castile Mining Company.....Ramsey, Mich.
Champion Copper Company.....Painesdale, Mich.
Chateaugay Ore & Iron Company.....Lyon Mountain, N. Y.
Chicago, Wilmington & Franklin Coal Co.....Chicago, Ill.
Cia Estanifera de Llallagua.....Llallagua, Bolivia, S. A.
Cincinnati Traction Company.....Cincinnati, Ohio
Cinco Minas Company.....Magdalena, Jalisco, Mexico
Cleveland-Cliffs Iron Company.....Ishpeming, Mich.
Copper Range Company (Baltic Mine Branch)...Baltic, Mich.
Cowanshannock Coal & Coke Company.....Yatesboro, Pa.
Davis-Daly Copper Company.....Butte, Mont.
Dering, J. K. Coal Company.....Clinton, Ind.
Ebensburg Coal Company.....Colver, Pa.
Ford Collieries Company.....Curtisville, Pa.
Frick, H. C. Coke Company.....Scottdale, Pa.
Gallup American Coal Company.....Gallup, New Mex.
Gasscock Collieries Company.....Morgantown, W. Va.
Gillespie Coal Company.....Gillespie, Ind.
Gilmore Coal Mining Company.....Pittsburgh, Pa.
Granby Consol. Mng., Smtg. & Power Co., Ltd...Phoenix, B. C.
Harris Coal Company.....Waukee, Iowa
Harrisburg Coal Mining Company.....Harrisburg, Ill.
Helena-Straven Coal Company.....Birmingham, Ala.
Hillside Fluorspar Mining Company.....Rosiclare, Ill.
Hollinger Consolidated Gold Mng. Co., Ltd..Timmins, Ont., Can.
Homestake Mining Company.....Lead, S. D.
Illinois Zinc Company.....Peru, Ill.
Juanita Coal & Coke Company.....Pueblo, Colo.
Judge Mining & Smelting Company.....Park City, Utah
Matthiessen & Hegeler Zinc Company.....La Salle, Ill.
McGeath Coal Company.....Omaha, Neb.
McKinney Steel Company.....Crystal Falls, Mich.
Mitsui Mining Company.....Tokyo, Japan
Mohawk Mining Company.....Mohawk, Mich.
Monarch Fuel Company.....Hollingsworth, Ky.
National Mining Company.....Scottdale, Pa.
Ontario Silver Mining Company.....Park City, Utah
Picands, Mather & Company.....Duluth, Minn.
Quincy Mining Company.....Hancock, Mich.
Republic Iron & Steel Company.....Duluth, Minn.
Sangamon County Mining Company.....Springfield, Ill.
Sayre Coal Mining Company, The.....Des Moines, Iowa
Shuler, Hugh.....Des Moines, Iowa
St. Bernard Coal Company.....Earlington, Ky.
Susquehanna Collieries Company.....Williamstown, Pa.
Trimountain Mining Company.....Trimountain, Mich.
Tennessee Coal, Iron & Railroad Company...Birmingham, Ala.
U. S. Smelting, Refining & Mining Co.....Salt Lake City, Utah
Utah Apex Mining Company.....Bingham Canyon, Utah
Utah Consolidated Mining Company....Bingham Canyon, Utah
West Penn Power Company.....Pittsburgh, Pa.
West Springs, Limited.....Johannesburg, South Africa
Wharton Steel Company.....Wharton, N. J.
Wilber Coal Mining Company.....Hooverville, Pa.
Witherbee-Sherman & Company.....Mineville, N. Y.
Woodward Iron Company.....Woodward, Ala.
Wolverine Mining Company.....Kearsarge, Mich.

BE PROGRESSIVE, FOLLOW THE BEST AUTHORITIES, AND STANDARDIZE ON THE LILLY CONTROLLER.

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ROBERT HOLMES & BROS., Inc.

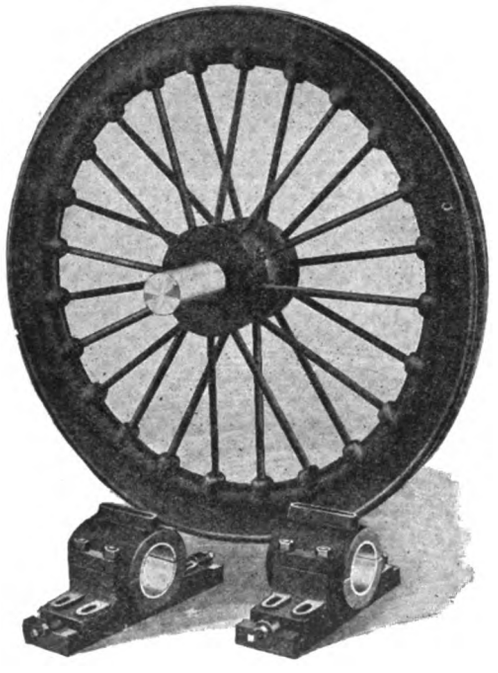
DANVILLE, ILL.

Builders of Equipment for Coal and Metal Mining

Products

Sheave Wheels—Plain Turned Groove and Steel Lined Groove; "Danville" Hoisting Engines; Skips, Cages, and Screen Equipment.

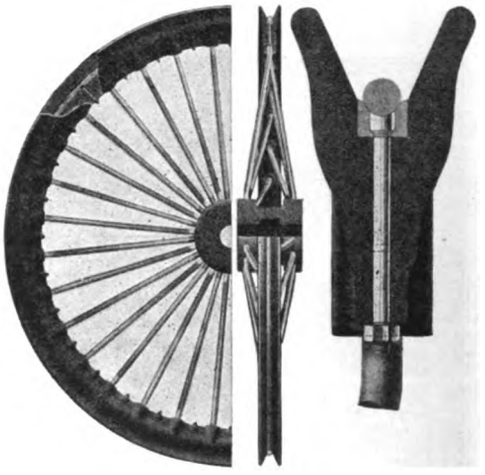
Special machinery made to your drawings at reasonable prices.



Plain Turned Groove Sheave Wheel and Boxes

Holmes Sheave Wheels, as shown by the accompanying cuts, are designed and built to give the utmost in durability and finish. They contain only the best of materials, melted to the correct per cent., insuring a perfect wheel in every respect.

Our wheels are made in two types, the plain turned groove and the steel lined groove as standards, but they can also be furnished with wood liners if so wanted. We suggest the steel lined wheel because the liners, being of a special hardened steel, will last much longer, and when worn can be replaced by a new set. The liners are made in sections and are interchangeable, this being a welcome feature. The rims of our wheels, as well as the hubs, are made strong enough to withstand most any task to which they might be put. Spokes are of wrought steel and so cast in the metal as to make them absolutely solid.



Sheave Wheel With Renewable Liner

We will be pleased to mail you a detailed print on request showing you the wonderful construction of this SUPER sheave. Wheels of either type can be had in sizes from four to fourteen feet in diameter and grooved to fit any size cable. A trial will convince you.

OUR CATALOG WILL BE SENT ON REQUEST

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LAKE SHORE ENGINE WORKS

MARQUETTE, MICHIGAN

Designers and Manufacturers of

Skips, Cages, Buckets and Sheaves

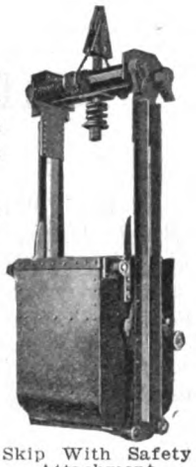
Products

Mine Cages and Skips; Skip Safety Devices; Dump Plates for Skips; Water Bailers; Water Buckets; Rope Sheaves; Mine Cars; Rotary Car Dumpers; Mine Car Wheels, Plain and Roller Bearing; Mine Car Trucks. For other products, see Pages 363, 402 and 403.

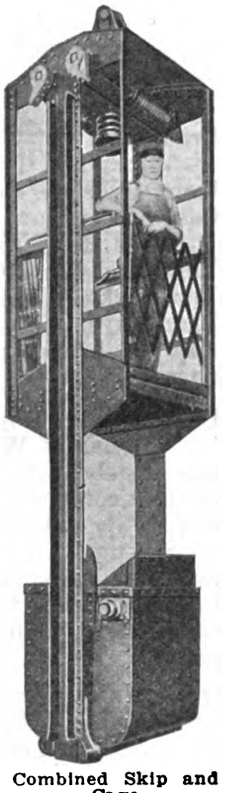
Mine Cages and Skips

Our experience in this line covers thirty years, and as it is impossible to show here a standard cage or skip, as the shaft compartments vary in size and general arrangement, we will illustrate some of the designs we have supplied, especially those on which there have been continued repeat orders.

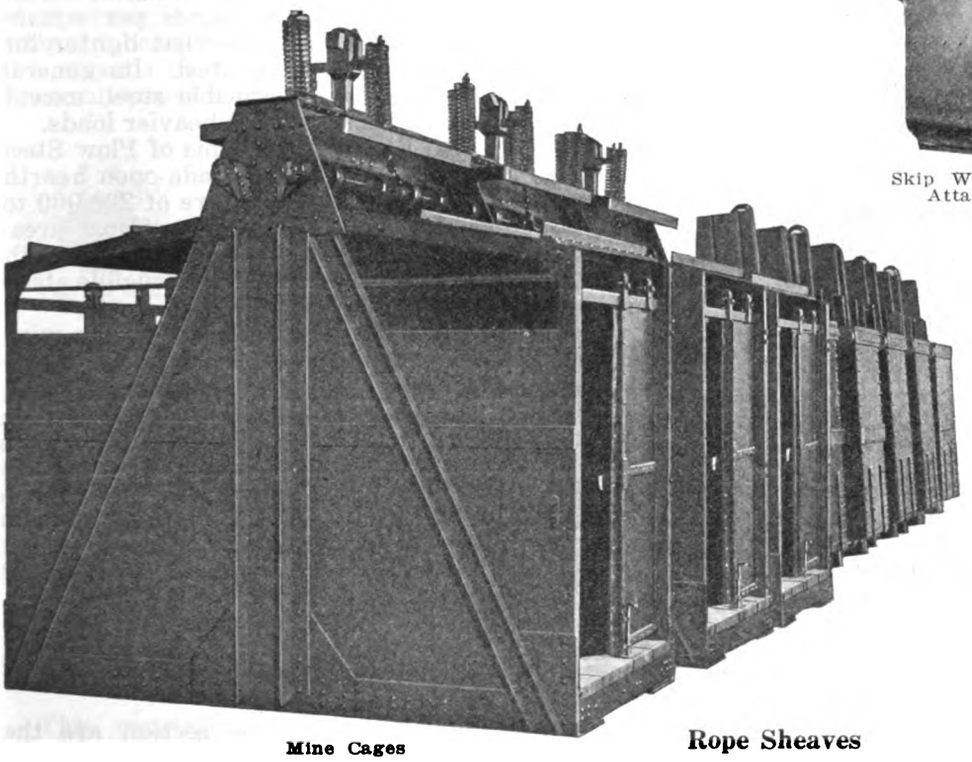
Our General Cage and Skip Catalog shows a more complete line of special types and designs.



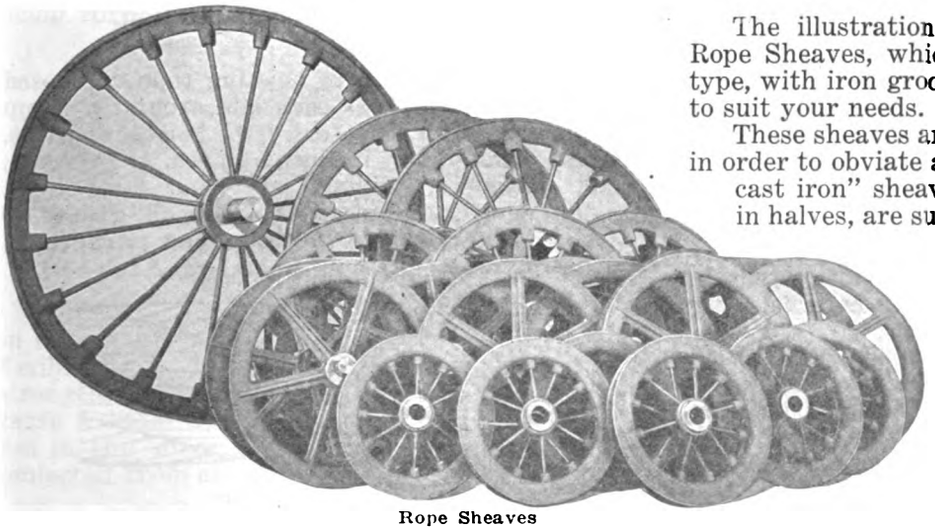
Skip With Safety Attachment



Combined Skip and Cage



Mine Cages



Rope Sheaves

Rope Sheaves

The illustration herewith shows a variety of Rope Sheaves, which can be furnished in Bicycle type, with iron groove or with wood lining, in sizes to suit your needs.

These sheaves are made with wrought iron arms in order to obviate any internal strain that the "all cast iron" sheaves, when made in one piece or in halves, are subject to. Our design also makes a lighter sheave, which is always an advantage in an idler. They are made with solid iron rim and with wood filling. In the latter design, the rim is turned accurately for the hardwood maple block.

We have standard sizes, all of which are listed in our General Car, Skip and Sheave Catalog.

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AMERICAN STEEL & WIRE CO.

Sales Offices:

CHICAGO.....208 So. La Salle Street
NEW YORK.....30 Church Street
WORCESTER.....94 Grove Street
BOSTON.....185 Franklin Street
PHILADELPHIA.....Widener Building
PITTSBURGH.....Frick Building
BUFFALO.....337 Washington Street
DETROIT.....Foot of First Street
CINCINNATI.....Union Trust Building
CLEVELAND.....Western Reserve Building
BALTIMORE.....32 So. Charles Street
WILKES-BARRE, PA.....Miners Bank Building
ST. LOUIS..Liberty Central Trust Company Bldg.
KANSAS CITY.....417 Grand Avenue
ST. PAUL-MINNEAPOLIS, Pioneer Bldg., St. Paul
OKLAHOMA CITY...1st National Bank Building
BIRMINGHAM, ALA.....Brown-Marx Building
DENVER.....1st National Bank Building
SALT LAKE CITY.....Walker Bank Building

Export Representative: U. S. Steel Products Co., New York
Pacific Coast Representative: U. S. Steel Products Company
San Francisco Los Angeles Portland Seattle

AMERICAN WIRE ROPE

Products

Wires and Cables in the following materials: Iron; Crucible Cast Steel; Extra Strong Crucible Cast Steel; Plow Steel; Monitor Steel.

Wire Rope Fittings and Accessories, including Thimbles, Clips, Clamps, Sockets, Hooks, Shackles, Turnbuckles, Blocks, Sheaves, see page 421; Aerial Tramways, see pages 508 to 511; Electrical Wires and Cables, see pages 266 to 269; Rail Bonds, see page 335.

Uses of Wire Rope

The use of Wire Rope for mechanical purposes has largely increased in recent years, so that it has almost completely superceded the older methods employing manila rope and steel or iron chain.

Strength, flexibility, elasticity, rigidity and, in fact, any desirable property may be obtained by an intelligent selection among the many grades and constructions shown on this and the succeeding pages.

Qualities of Wire Rope

IRON ROPE—In the early days of mining, Iron was used exclusively in the manufacture of wire rope, succeeding the hemp ropes. In turn, Iron Rope has given way to steel, because of the stronger and tougher qualities of the latter material. The physical characteristics of Iron Rope are softness, ductility and low tensile strength, the latter being approximately 85,000 pounds per square inch in the drawn wire entering into ropes. Iron Rope is most generally used for elevator hoisting, where the strength is sufficient.

CRUCIBLE CAST STEEL ROPE—This brand of steel derives its name from the early method of making carbon steel which could be hardened. It was formerly made in crucibles, small enough to be operated by hand and containing from 50 to 100 pounds of steel each. The same grade of steel for rope is now made by the open hearth furnace, which not only yields a much larger quantity of material, but, moreover, produces a steel which is of more uniform composition. The area is only about one-half that of iron of the same strength, while the steel is harder and resists external wear to a greater degree.

Crucible Cast Steel Rope is applicable to such uses as mine hoists, derricks, dredges, cableways, incline planes and many others. When turned into wire and properly treated, the crucible open hearth steel will have a tensile strength of from 180,000 to 200,000 pounds per square inch of sectional area.

EXTRA STRONG CRUCIBLE CAST STEEL ROPE—This, as it name implies, is a stronger grade of crucible open hearth steel of somewhat tougher chemical composition and strength, which runs from 200,000 to 220,000 pounds per square inch of sectional area. It is somewhat lighter for the same strength than crucible steel. Its general uses are similar to those of crucible steel, except that it may be used for somewhat heavier loads.

PLOW STEEL ROPE—The name of Plow Steel as applied to rope means a high-grade open hearth steel of a tensile strength in the wire of 220,000 to 240,000 pounds per square inch of sectional area. Plow Steel combines lightness with great strength and is nearly three times as strong as crucible steel, but somewhat stiffer.

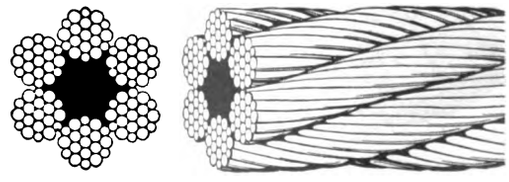
Plow Steel Rope is used largely for heavy mine hoisting, derricks, inclined planes, dredges, cableways and similar uses. It is a most economical rope to use where the weight of the rope is to be considered, or where the capacity of the machinery has to be increased without a corresponding increase in sheaves and drums.

MONITOR STEEL ROPE—This rope is made of a very carefully selected grade of open hearth steel wire having a tensile strength of from 240,000 to 280,000 pounds per square inch of sectional area. This is the highest strength rope made. It is somewhat stiffer in the same diameter than plow and crucible steel grades, but strength for strength, it is equally flexible.

The ropes illustrated in this section are the ones most frequently used. Special grades and constructions can be furnished on application.

Standard Hoisting Rope

This term is applied to hoisting rope composed of 6 strands of 19 wires each laid around a hemp core. It is used for elevators, mine hoists, derricks, dredges, cableways, inclined planes, conveyors, ballast unloaders, drilling cable and tube lines. Standard Hoisting Rope is made in all grades of material as described in the foregoing paragraphs on construction.



Standard Hoisting Rope

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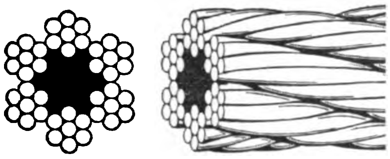
Transmission, Haulage or Standing Rope

Made in 6 strands, 7 wires to the strand, with 1 hemp core. Principally used for mine haulage, on inclined planes and tramways. Withstands wear well.



Transmission, Haulage or Standing Rope

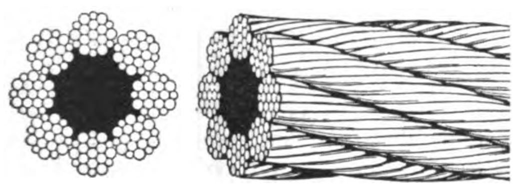
Made in 5 grades, as shown in accompanying table.

DATA TABLE—TRANSMISSION, HAULAGE OR HOISTING ROPE

Diameter in Inches	Weight per Foot in Pounds	Iron		Crucible Cast Steel		Crucible Cast Steel Extra Strong		Plow Steel		Monitor Steel	
		Proper Working Load in Tons of 2000 Pounds	List Price per Foot	Proper Working Load in Tons of 2000 Pounds	List Price per Foot	Proper Working Load in Tons of 2000 Pounds	List Price per Foot	Proper Working Load in Tons of 2000 Pounds	List Price per Foot	Proper Working Load in Tons of 2000 Pounds	List Price per Foot
1½	3.55	6.4	$0.51	12.6	$0.60	14.6	$0.75	16.4	$0.90	18	$1.05
1⅜	3	5.6	.43	10.6	.51	12.6	.64	14.4	.76	16	.88
1¼	2.45	4.6	.36	9.2	.43	10.8	.53	12	.62	13	.72
1⅛	2	3.8	.30	7.4	.36	8.6	.44	9.4	.51	10	.58
1	1.58	3	.24	6.2	.29	7	.35	7.6	.41	8.4	.48
⅞	1.20	2.4	.18½	4.8	.22½	5.6	.27	6.2	.32	6.6	.37
¾	.89	1.7	.14	3.7	.17	4.2	.20	4.6	.24½	5	.28½
11/16	.75	1.5	.12	3.1	.14½	3.3	.17	3.6	.21	4	.24½
⅝	.62	1.2	.10	2.6	.12	2.9	.14¼	3.2	.17½	3.5	.20½
9/16	.50	.96	.08¼	2	.10	2.2	.12	2.4	.14½	2.6	.17
½	.39	.74	.06½	1.5	.08	1.8	.09½	2	.11½	2.2	.13½
7/16	.30	.52	.05½	1.1	.06½	1.25	.07½	1.4	.09	1.5	.11½
⅜	.22	.44	.04½	.92	.05½	1.05	.06	1.2	.06¾	1.3	.08¾
5/16	.15	.34	.03¾	.70	.04½	.79	.05½	.88	.06	....	....
9/32	.12½	.24	.03¼	.50	.04	.59	.05	.68	.05½	....	....

Extra Flexible Hoisting Rope

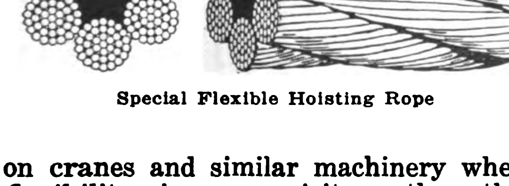
This term is applied to rope composed of 8 strands of 19 wires each laid around a hemp core. The addition of the two strands over the Standard Hoisting Rope construction increases the flexibility and permits of the rope being used over comparatively smaller sheaves and drums. It is adapted for derricks, steam dredges, ore handling machinery, pile drivers, tubing lines and drilling cables. It is made in all grades of material mentioned.



Extra Flexible Hoisting Rope

Special Flexible Hoisting Rope

This construction is composed of 6 strands of 37 wires each laid around a hemp core. It is very flexible and used on cranes and similar machinery where flexibility is a requisite rather than strength. It is a very efficient rope, because a little over 50% of its strength lies in the inner layers of the strands, protected from abrasion.



Special Flexible Hoisting Rope

DATA, VARIOUS CONSTRUCTIONS AND GRADES OF WIRE HOISTING ROPE

Diam. in ins.	Weight per ft. in lbs.	Iron			Crucible Cast Steel			Extra Strong Crucible Cast Steel		Plow Steel		Monitor Steel	
		Proper working load in tons of 2000 lbs.	Diam. of drum or sheave in ft. advised	List price per ft.	Proper working load in tons of 2000 lbs.	Diam. of drum or sheave in ft. advised	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.
HOISTING ROPE—6 STRANDS, 19 WIRES TO STRAND, 1 HEMP CORE													
2¾	11.95	22.2	17	$1.70	42.2	11	$2.10	48.6	$2.55	55	$3.00	63	$3.45
2½	9.85	18.4	15	1.40	34	10	1.75	40	2.10	46	2.50	53	2.80
2¼	8	14.4	14	1.17	26.6	9	1.44	32	1.70	37	2.00	42	2.50
2	6.30	11	12	.95	21.2	8	1.16	24.6	1.34	28	1.58	33	1.85
1⅞	5.55	10	12	.88	19	8	1.02	22.4	1.25	25	1.46	30	1.75
1¾	4.85	8.8	11	.80	17	7	.90	19.8	1.10	22	1.30	27	1.60
1⅝	4.15	7.6	10	.65	14.4	6.5	.77	16.6	.94	19	1.08	22	1.30
1½	3.55	6.6	9	.57	12.8	6	.66	14.6	.80	16	.93	20	1.10
1⅜	3	5.6	8.5	.49	11.2	5.5	.56	12.8	.68	14	.79	17	.90
1¼	2.45	4.56	7.5	.40	9.4	5	.46	10.6	.56	12	.65	14	.75
1⅛	2	3.72	7	.33	7.6	4.5	.38	8.6	.46	9.4	.54	11	.62
1	1.58	2.90	6	.26	6	4	.31	6.80	.37	7.6	.43	9	.50
⅞	1.20	2.36	5.5	.20	4.6	3.5	.24	5.20	.29	5.8	.34	7	.39
¾	.89	1.70	4.5	.16	3.5	3	.19	4.04	.22	4.6	.26	5.3	.31
⅝	.62	1.20	4	.12	2.5	2.5	.14	2.80	.16½	3.1	.19	3.8	.22½
9/16	.50	.94	3.5	.10	2	2.25	.12	2.24	.14	2.4	.16	2.9	.19
½	.39	.78	3	.08½	1.68	2	.11	1.84	.12½	2	.14	2.4	.17
7/16	.30	.58	2.75	.07½	1.30	1.75	.10	1.45	.11½	1.6	.13	1.9	.15½
⅜	.22	.48	2.25	.07	.96	1.50	.09½	1.06	.11	1.15	.12½	1.35	.14½
5/16	.15	.30	2	.06¾	.62	1.25	.09¼	.70	.10¾	.76	.12¼	.9	.13½
¼	.10	.22	1.50	.06½	.44	1.00	.09	.49	.10½	.53	.12	.63	.13
EXTRA FLEXIBLE HOISTING ROPE—8 STRANDS, 19 WIRES TO STRAND, 1 HEMP CORE													
1½	3.19				11.6	3.75	$0.73	13	$0.88	14.8	$1.03	16	$1.19
1⅜	2.70				10.2	3.5	.62	11	.75	12.8	.87	13	.98
1¼	2.20				8.4	3.2	.51	9.4	.62	10.4	.72	11	.82
1⅛	1.80				6.8	2.83	.42	7.6	.51	8.6	.60	9.2	.68
1	1.42				5.2	2.5	.34	5.9	.41	6.6	.48	7.2	.55
⅞	1.08				4	2.16	.27	4.6	.32	5.2	.38	5.6	.43
¾	.80				3.06	1.83	.21	3.5	.25	4	.29	4.4	.34
⅝	.56				2.18	1.75	.16	2.5	.18½	2.8	.21	3	25
9/16	.45				1.74	1.5	.14	2	.16	2.32	.18	2.4	.22
½	.35				1.46	1.33	.12	1.6	.14	1.74	.16	1.9	.19
7/16	.27				1.14	1.16	.11	1.26	.13	1.38	.15		
⅜	.20				.84	1	.10½	.93	.12¼	1.02	.14		
5/16	.13				.55	.83	.10¼	.61	.12	.67	.13½		
¼	.09				.36	.75	.10	.40	.11¾	.45	.13¼		
SPECIAL FLEXIBLE HOISTING ROPE—6 STRANDS, 37 WIRES TO STRAND, 1 HEMP CORE													
2¾	11.95				40		$2.30	47	$2.80	53	$3.30	55	$3.75
2½	9.85				32		1.92	37	2.35	43	2.75	45	3.15
2¼	8				25		1.60	30	1.90	35	2.20	37	2.50
2	6.30				21		1.35	23	1.55	26	1.80	27	2.10
1⅞	5.55				18.8		1.20	21.2	1.41½	23.8	1.65	25	1.92½
1¾	4.85				17		1.05	19	1.28	22	1.50	23	1.75
1⅝	4.15				14		.89	16	1.07	18	1.25	19	1.45
1½	3.55				12	3.75	.79	14	.95	16	1.10	17	1.25
1⅜	3				11	3.5	.65	12	.78	14	.91	14	1.05
1¼	2.45				9	3.2	.55	10	.65	11	.75	11	.86
1⅛	2				7	2.83	.46	8	.55	9	.64	9.2	.75
1	1.58				6	2.5	.37	6.4	.44	7	.51	7.4	.59
⅞	1.20				5	2.16	.28	5	.34	5	.40	5.8	.46
¾	.89				3.5	1.83	.23	3.8	.27	4	.31	4.6	.36
⅝	.62				2.2	1.75	.18	2.5	.21	3	.24	3.2	.27
9/16	.50				1.9	1.5	.15	2.1	.17½	2.3	.20	2.5	.23
½	.39				1.45	1.33	.13	1.65	.15	1.85	.17	1.9	.20
7/16	.30				1.1	1.16	.12½	1.27	.14	1.4	.16	1.5	.18½
⅜	.22				.84	1	.12	.93	.13	1	.15	1.06	.17½

Diameter of drum advised for extra strong crucible cast steel, plow steel and monitor steel rope is same as for crucible cast steel.

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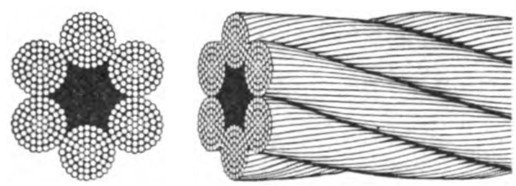
Extra Special Flexible Hoisting Rope

Composed of 6 strands of 61 wires each with one hemp core. It is recommended for dredging purposes, for which it is usually made with a special steel center. Furnished in Crucible Cast Steel; Extra Strong Crucible Cast Steel; Plow Steel and Monitor Steel.



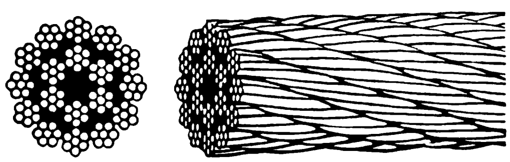
Extra Special Flexible Hoisting Rope

DATA, EXTRA SPECIAL FLEXIBLE HOISTING ROPE
6 Strands, 61 Wires to Each, 1 Hemp Core

			Crucible Cast Steel		Extra Strong Crucible Cast Steel		Plow Steel		Monitor Steel	
Diam. in ins.	Weight per ft. in lbs.	Diam. of drum or sheave in ft. advised	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.
3¼	16.60	11	56		63		70		74	
3	14.20	10	48		55		62		65	
2¾	11.96	9	40	$2.53	47	$3.08	63	$3.63	56	$4.12
2½	9.85	8	32	2.112	37	2.58	43	3.02	45	3.46
2¼	8.00	7	25	1.76	30	2.09	35	2.42	37	2.75
2	6.30	6	21	1.48	23	1.70	26	1.98	27	2.31

Non-Spinning Hoisting Rope

This rope contains 18 strands of 7 wires each laid around a hemp core. It is stronger than the Crucible Cast Steel and will carry somewhat heavier loads, and is especially adapted for single line derricks, mine shaft sinking, etc. It will not overwind on the drum.



Non-Spinning Hoisting Rope

DATA, NON-SPINNING HOISTING ROPE
18 Strands, 7 Wires Each, 1 Hemp Core

			IRON		CRUCIBLE CAST STEEL		EXTRA STRONG CRUCIBLE CAST STEEL		PLOW STEEL		MONITOR STEEL	
Diam. in ins.	Weight per ft. in lbs.	Diam. of drum or sheave in ft. advised	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.
1¾	5.50	7.00	9.1	$0.80	17.1	$0.90	20.2	$1.10	22.2	$1.30	24.4	$1.60
1⅝	4.90	6.50	7.9	.65	14.8	.77	17.5	.94	19.2	1.08		
1½	4.32	6.00	6.8	.57	12.7	.66	15.0	.80	16.5	.93	18.1	1.10
1⅜	3.60	5.50	5.6	.49	10.4	.56	12.4	.68	13.7	.79	15.1	.90
1¼	2.80	5.00	4.6	.40	8.7	.46	10.3	.56	11.3	.65	12.5	.75
1⅛	2.34	4.50	3.9	.33	7.3	.38	8.6	.46	9.5	.54	10.4	.62
1	1.73	4.00	2.9	.26	5.6	.31	6.6	.37	7.2	.43	7.8	.50
⅞	1.44	3.50	2.3	.20	4.5	.24	5.3	.29	6.3	.34	7.0	.39
¾	1.02	3.00	1.7	.16	3.3	.19	3.9	.22	4.9	.26	5.4	.31
⅝	.70	2.50	1.1	.12	2.2	.14	2.6	.16½	3.1	.19	3.4	.22½
9/16	.87	2.25	.97	.10	1.8	.12	2.1	.14	2.5	.16		
½	.42	2.00	.73	.08½	1.3	.11	1.6	.12½	1.9	.14	2.1	.17
7/16	.31	1.75	.52	.07½	.98	.10	1.1	.11½	1.3	.13		
⅜	.25	1.50	.42	.07	.78	.09½	.92	.11	1.1	.12½	1.2	.14½

Made in five grades: Iron; Crucible Cast Steel; Extra Strong Crucible Cast Steel; Plow Steel; Monitor Steel.

Steel Clad Hoisting Rope

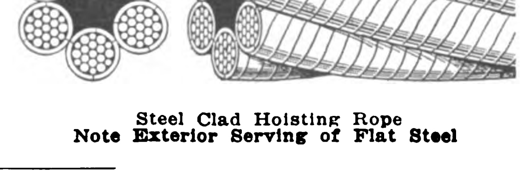
Composed of 6 strands of 19 wires each, the strands having been given an external serving of flat strip steel, wound spirally around each strand. When the outer flat steel winding is worn through in service, a complete hoisting rope remains with unimpaired strength, the strip having served to protect the inner wires up to this point. When roughly worn, the strip naturally crowds down between the strands of the rope, thus providing additional wearing surface.

Rope of this construction may be used for unusually severe conditions, such as on dredges, steam shovels, drag line excavators and the like.

Made in four grades: Crucible Cast Steel; Extra Strong Crucible Cast Steel; Plow Steel; Monitor Steel.

DATA, STEEL-CLAD HOISTING ROPE
6 Strands, 19 Wires to Strand

			CRUCIBLE CAST STEEL		EXTRA STRONG CRUCIBLE CAST STEEL		PLOW STEEL		MONITOR STEEL	
Diam. in ins.	Weight per ft. in lbs.	Diam. of drum or sheave in ft. advised	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.	Proper working load in tons of 2000 lbs.	List price per ft.
2¼	8.45	8	21.2	$1.56	24.6	$1.74	28	$1.98	33	$2.25
2	6.70	7.5	19.2	1.29	22.4	1.52	25	1.73	30	2.02
1⅞	6.02	7	17.0	1.16	19.8	1.36	22	1.56	27	1.86
1¾	5.25	6.5	14.4	1.01	16.6	1.18	19	1.32	22	1.54
1⅝	4.62	6	12.8	.89	14.6	1.03	16	1.16	20	1.33
1½	3.95	5.5	11.2	.78	12.8	.90	14	1.01	17	1.12
1⅜	3.30	5	9.4	.67	10.6	.77	12	.86	14	.96
1¼	2.80	4.5	7.6	.57	8.6	.65	9.4	.73	11	.81
1⅛	2.12	4	6.0	.49	6.8	.55	7.6	.61	9	.68
1	1.72	3.5	4.6	.41	5.2	.46	5.8	.51	7	.56
⅞	1.30	3	3.5	.36	4.04	.39	4.6	.43	5.3	.48
¾	1.00	2.5	2.5	.30	2.80	.32	3.1	.35	3.8	.38
⅝	.70	2	1.68	.26	1.84	.27	2.0	.29	2.4	.32



Steel Clad Hoisting Rope
Note Exterior Serving of Flat Steel

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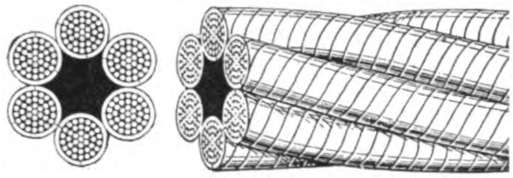
Steel Clad Special Flexible Hoisting Rope

Made of 6 strands of 37 wires each and protected by steel strips wound spirally around the



Steel Clad Special Flexible Hoisting Rope

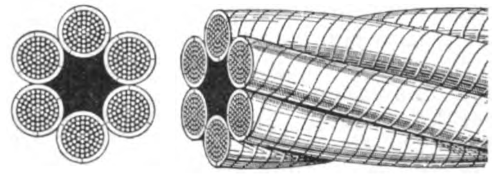
strands in the same manner as in Steel Clad Hoisting Rope, but having greater flexibility. Made in the same grades as Steel Clad Hoisting Rope.

DATA, STEEL CLAD, SPECIAL FLEXIBLE HOISTING ROPE
6 Strands, 37 Wires to Strand, 1 Hemp Core

Diam. in ins.	Weight per ft. in lbs.	Diam. of drum or sheave in ft. advised	Crucible Cast Steel: Proper working load in tons of 2000 lbs.	Crucible Cast Steel: List price per ft.	Extra Strong Crucible Cast Steel: Proper working load in tons of 2000 lbs.	Extra Strong Crucible Cast Steel: List price per ft.	Plow Steel: Proper working load in tons of 2000 lbs.	Plow Steel: List price per ft.	Monitor Steel: Proper working load in tons of 2000 lbs.	Monitor Steel: List price per ft.
2¾	12.05	8	32	$2.52	37	$2.95	43	$3.35	45	$3.75
2½	9.90	7	25	2.10	30	2.40	35	2.70	37	3.00
2¼	8.00	6	21	1.75	23	1.95	26	2.20	27	2.50
2	6.60	5.25	18.8	1.47	21.2	1.68	23.8	1.92	25	2.19
1⅞	5.90	4.75	17	1.31	19	1.54	22	1.76	23	2.01
1¾	4.90	4.25	14	1.13	16	1.31	18	1.49	19	1.69
1⅝	4.30	3.75	12	1.02	14	1.18	16	1.33	17	1.48
1½	3.75	3.5	11	.87	12	1.00	14	1.13	14	1.27
1⅜	3.05	3.2	9	.76	10	.86	11	.96	11	1.07
1¼	2.40	2.83	7	.65	8	.74	9	.83	9.2	.94
1⅛	2.00	2.5	6	.55	6.4	.62	7	.69	7.4	.77
1	1.75	2.16	5	.45	5	.51	5	.57	5.8	.63

Steel Clad Extra Special Flexible Hoisting Rope

Made of 6 strands of 61 wires each in the same manner as the two ropes mentioned pre-



Steel Clad Extra Special Flexible Hoisting Rope

viously, but possessing greater flexibility than either. Made in four grades, the same as those two previously described.

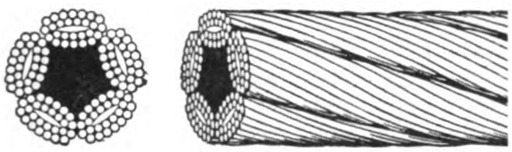
DATA, STEEL CLAD, EXTRA SPECIAL FLEXIBLE HOISTING ROPE

6 Strands, 61 Wires to Strand, 1 Hemp Core

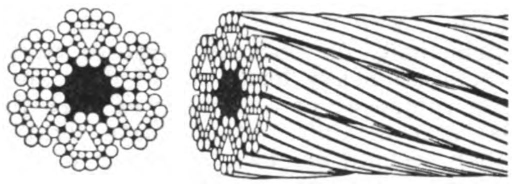
Diam. in ins.	Weight per ft. in lbs.	Diam. of drum or sheave in ft. advised	Crucible Cast Steel: Proper working load in tons of 2000 lbs.	Crucible Cast Steel: List price per ft.	Extra Strong Crucible Cast Steel: Proper working load in tons of 2000 lbs.	Extra Strong Crucible Cast Steel: List price per ft.	Plow Steel: Proper working load in tons of 2000 lbs.	Plow Steel: List price per ft.	Monitor Steel: Proper working load in tons of 2000 lbs.	Monitor Steel: List price per ft.
3¼	16.80	10	48	$3.90	55	$4.55	62	$5.10	65	$5.70
3	14.35	9	40	3.23	47	3.78	53	4.33	55	4.82
2¾	12.05	8	32	2.71	37	3.18	43	3.62	45	4.06
2½	9.90	7	25	2.26	30	2.59	35	2.92	37	3.25
2¼	8.45	6	21	1.88	23	2.10	26	2.38	27	2.71

Flattened Strand Hoisting or Transmission Rope

These ropes compare in flexibility with the Standard Hoisting Rope, but expose about 150% greater wearing surface than the round strand ropes of the same diameter, and have been used generally in the same places.



Type A



Type B

Made in four grades: Iron; Crucible Cast Steel; Extra Strong Crucible Cast Steel; Monitor Steel.

FLATTENED STRAND HOISTING ROPES
Type A—5 Strands. 28 Wires Each. 1 Hemp Core — Type B—6 Strands. 25 Wires Each. 1 Hemp Core

Diam. in ins.	Iron, Type A: Proper working load in tons of 2000 lbs.	Iron, Type A: Weight per ft. in lbs.	Iron, Type A: Diam. of drum or sheave in ft. advised	Iron, Type A: List price per ft.	Crucible Cast Steel, Type A: Proper working load in tons of 2000 lbs.	Crucible Cast Steel, Type B: Proper working load in tons of 2000 lbs.	Crucible Cast Steel, Type B: Weight per ft. in lbs.	Crucible Cast Steel, Types A & B: Diam. of drum or sheave in ft. advised	Crucible Cast Steel, Types A & B: List price per ft.	Extra Strong Crucible Cast Steel*, Type A: Proper working load in tons of 2000 lbs.	Extra Strong Crucible Cast Steel*, Type B: Proper working load in tons of 2000 lbs.	Extra Strong Crucible Cast Steel*, Types A & B: List price per ft.	Monitor Steel, Type A: Proper working load in tons of 2000 lbs.	Monitor Steel, Type B: Proper working load in tons of 2000 lbs.	Monitor Steel, Types A & B: Diam. of drum or sheave in ft. advised	Monitor Steel, Types A & B: List price per ft.
2¼	14.4	8.00	11¼	$1.52	26.6	29.2	9.20	8½	$1.82	32	35.2	$2.20	42	46.2	12	$2.85
2	11	6.30	10¾	1.20	21.2	23.4	7.25	8	1.44	24.6	27	1.77	33.2	36.2	11	2.25
1¾	8.8	4.85	9	1.04	17.0	18.8	5.60	7¼	1.21	19.8	21.8	1.55	26.6	29.2	9	2.08
1⅝	7.6	4.15	7½	.82	14.4	15.8	4.75	6¼	.96	16.6	18.2	1.30	22	24.2	8½	1.56
1½	6.6	3.55	6¾	.74	12.8	14.0	4.00	5¾	.86	14.6	16	1.05	19.6	21.6	8	1.37
1⅜	5.6	3.00	6¼	.625	11.2	12.4	3.45	5½	.73	12.8	14.0	.90	16.8	18.4	7½	1.12
1¼	4.56	2.45	5¾	.52	9.4	10.4	2.80	5	595	10.6	11.6	.70	13.8	15.2	7	.89
1⅛	3.72	2.00	5¼	.43	7.6	8.4	2.30	4½	.50	8.6	9.4	.59	11.2	12.4	6	.71
1	2.90	1.58	4¾	.34	6.0	6.6	1.80	4	.395	6.8	7.4	.48	9	10.0	5	.60
⅞	2.36	1.20	4	.26	4.6	5.0	1.38	3½	.30	5.2	5.8	.38	7	7.8	4½	.19
¾	1.70	.89	3½	.21	3.5	3.86	1.00	3	.24	4.04	4.44	.30	5.26	5.8	4	.375
⅝	1.20	.62	3	.155	2.5	2.76	.72	2¼	.18¼	2.80	3.08	.225	3.8	4.2	3½	.28
9/16	.94	.50	2½	.13	2	2.2	.58	1¾	.165	2.24	2.46	.195	2.9	3.2	3	.25
½	.78	.39	2	.105	1.68	1.86	.45	1½	.145	1.84	2.02	.175	2.42	2.7	2¾	.20¾
⅜	.48	.22	1	.095												

Weights for Types A and B respectively are the same for all constructions.
*Diameters of drums are the same as for Crucible Cast Steel.
Standard plow steel grade is also furnished if desired.

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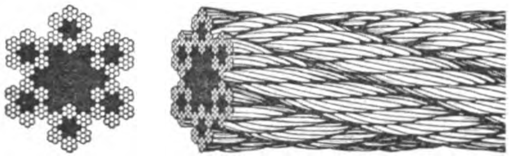
Tiller Rope or Hand Rope

Is used principally for signal pull purposes in mines and factories and in connection with the operating and controlling of signalling devices on elevators. It is composed of 6 strands of 42 wires each, each strand being a little wire rope in itself. This rope has seven hemp cores, one large one in the center of the rope, and one little one in each of



Tiller Rope

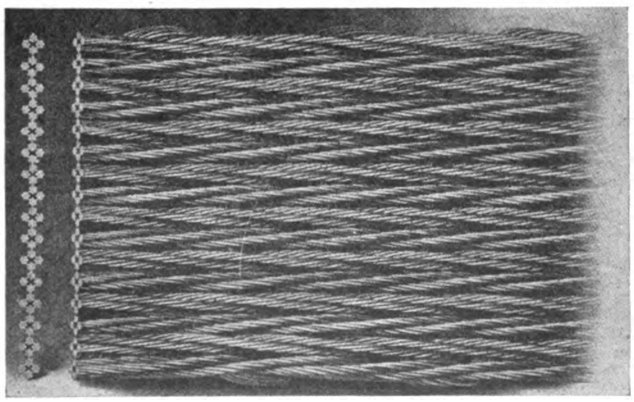
the six strands. It is an exceptionally flexible rope and is capable of being bent around very small sheaves. However, it will withstand very little abrasion on account of the fine wires of which it is composed.

TILLER ROPE
6 Strands of 42 Wires Each—252 Wires in All—7 Hemp Cores

Diameter in Inches	Approx. Weight per Foot in Pounds	Diam. of Drum or Sheave in Inches Advised	List Price Per Foot	
			Iron	Crucible Cast Steel
1	1.10	24	$0.33	$0.43
⅞	.84	21	.27	.36
¾	.62	18	.22	.30
⅝	.43	15	.17	.24
9/16	.35	13½	.14	.20
½	.28	12	.11½	.17
7/16	.21	10½	.10	.15
⅜	.16	9	.09	.14
5/16	.11	7½	.08	.12½
¼	.07	6	.07½	.11
3/16	.042	....	.07	.10

Flat Rope

Used principally for hoisting purposes, particularly for hoisting heavy loads out of deep shafts. The rope is composed of a number of wire ropes called "flat rope strands," of alternate right and left lay, then secured or sewed together with soft iron or steel wire, thus forming a complete rope



Flat Rope

as shown in the illustration. It is usually made of crucible steel, although iron or plow steel can be used if necessary. When the sewing wires are worn through, the flat rope can be re-sewed with new wire and if any of the rope strands are also worn or damaged, these can be replaced with new portions. In fact, Flat Rope admits of being repaired by the replacing of any worn or injured part. Strands of any kind, size or quality can be furnished.

Flat Rope can be furnished from 1¾ to 8 inches in width, and from ¼ to ⅞ inches in thickness, the length varying from 20 to 3,000 feet.

FLAT ROPE
Crucible Steel—Plow Steel

Width and thickness in ins.	Weight per ft. in lbs.	Crucible Steel: Proper working load in tons of 2000 lbs.	Plow Steel: Proper working load in tons of 2000 lbs.	Width and thickness in ins.	Weight per ft. in lbs.	Crucible Steel: Proper working load in tons of 2000 lbs.	Plow Steel: Proper working load in tons of 2000 lbs.
¼x1½	0.65	2.6	3.10	½x2½	2.20	9.0	10.8
¼x2	0.82	3.4	4.00	½x3	2.50	10.4	12.6
¼x2½	1.06	4.4	5.30	½x3½	2.80	12.0	14.4
¼x3	1.23	5.2	6.20	½x4	3.15	13.8	16.4
5/16x1½	0.79	3.6	4.4	½x4½	3.85	16.6	19.8
5/16x2	1.10	4.6	5.6	½x5	4.20	18.0	21.6
5/16x2½	1.35	6.0	7.0	½x5½	4.55	19.6	23.6
5/16x3	1.60	7.2	8.6	½x6	4.90	21.0	25.2
5/16x3½	1.88	8.2	10.0	½x7	5.90	25.6	30.6
5/16x4	2.15	9.6	11.4	⅝x3½	3.50	13.6	15.8
⅜x2	1.30	5.4	6.6	⅝x4	4.00	15.8	18.4
⅜x2½	1.70	7.2	8.6	⅝x4½	4.55	18.2	21.0
⅜x3	1.89	8.2	9.8	⅝x5	5.10	20.4	23.8
⅜x3½	2.30	10.0	12.0	⅝x5½	5.65	22.8	26.4
⅜x4	2.43	10.8	13.0	⅝x6	6.15	25.0	29.0
⅜x4½	2.85	12.6	15.2	⅝x7	7.30	29.6	34.2
⅜x5	3.10	13.6	16.2	⅝x8	8.40	34.0	39.4
⅜x5½	3.50	15.4	18.4	¾x5	6.85	27.0	31.4
⅜x6	3.73	16.2	19.4	¾x6	7.50	27.0	30.2
				¾x7	8.25	33.6	38.8
				¾x8	9.75	40.4	46.8
				⅞x5	7.50	31.0	34.4
				⅞x6	8.53	36.0	41.8
				⅞x7	9.56	40.6	46.6
				⅞x8	10.60	45.0	51.6

Galvanized Rope

Galvanized Rope is made in many grades and constructions to meet varying conditions of service. It is used where exposure to the weather, constant or periodical moisture, etc., are among the conditions that tend to corrode a rope not protected in this way.

Galvanized Rope is not adapted to general outdoor hoisting work, as the zinc on the wires will not stand such service.

Galvanized Rope is especially adapted to "standing" service, wherein no bending is encountered, such as guys for derricks and smokestacks.

Made in the following grades:

Iron—Six strands, 7 wires each, 1 hemp core.

Iron—Six strands, 12 wires each, 1 hemp core.

Iron—Six strands, 12 wires each, 7 hemp cores.

Crucible Cast Steel—Six strands, 7 wires each, 1 hemp core.

Crucible Cast Steel—Six strands, 19 wires each, 1 hemp core.

Crucible Cast Steel—Six strands, 12 wires each, 7 hemp cores.

Crucible Cast Steel—Six strands, 24 wires each, 7 hemp cores.

Plow Steel—Six strands, 12 wires each, 7 hemp cores.

Galvanized Arc Light Rope—Nine strands, 4 or 7 wires each, 1 hemp core.

Galvanized Standing Rope

Data as to sizes, weights and prices furnished on application.

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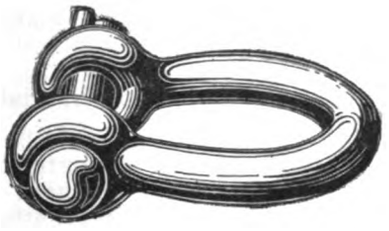
Wire Rope Fittings and Accessories

The successful use of wire rope frequently depends on the selection of fittings or end-fastenings. Therefore, we endeavor to carry a large stock of fittings in various warehouses, together with skilled labor for attaching them. Some of these fittings are clamped to the wire rope; some are fastened with molten metal; others are spliced on.

Fittings may be purchased either loose or attached. If attached, great care should be exercised in submitting specifications, lest error be made in the length of rope overall.

Iron Guy Shackles

These shackles are used as neck ropes, the ends of which are clipped with thimbles, sockets, turnbuckles, etc. Indispensable for general mine use.

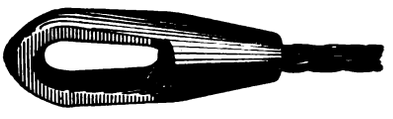


Iron Guy Shackle

Open and Closed Sockets

For use with either steel or iron rope. As we attach them, they are the strongest rope fastenings made. All standard type sockets are drop forged weldless and stronger than any rope that may be inserted in them.

Open Socket



Closed Socket

Socket and Chain

Made for any size of rope, price depending on length and size of chain.

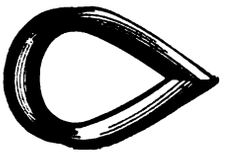
Socket and Chain

Turnbuckles

Turnbuckles are necessary to take up slack in rope in many places, such as in guy ropes, etc. They are made with Hook and Eye; Eyes both ends; Eye and Clevis; and Clevises both ends.

Galvanized Oval Thimbles

Our oval thimbles are heavily coated with zinc and made in various sizes.

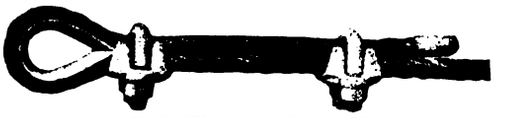


Large Size

Small Size

A. S. & W. Wire Rope Clips

These are not recommended for permanent fastenings on hoist rope, but are universally used on ropes supporting screens, loading booms, etc.



A. S. & W. Wire Rope Clips

TABLE ON SHACKLES

Sizes in Inches of Shackle (Diam. of Iron in Bow)	Gov. Test Max. Strength in Pounds	Length Inside Inches	Width Between Eyes Inches	Diam. of Pin in Inches	Approximate Weight of Each in Pounds
3/8	10,890	1 3/8	5/8	1/2	0.30
7/16	15,200	1 3/4	13/16	9/16	0.48
1/2	18,390	1 7/8	13/16	5/8	0.70
9/16	24,800	1 7/8	7/8	11/16	0.90
5/8	33,400	2 1/4	1 3/16	3/4	1.40
3/4	43,400	3	1 9/32	7/8	2.20
7/8	55,200	3 1/2	1 3/8	1	3.40
1	74,900	4	1 1/4	1 1/8	5.00
1 1/8	90,200	4 1/2	1 7/8	1 1/4	6.80
1 1/4	92,040	5	2	1 3/8	9.40
1 3/8	94,100	5 1/2	2 1/8	1 1/2	12.20
1 1/2	103,800	6	2 1/4	1 5/8	16.40
1 5/8	155,542	6 1/2	2 1/2	1 3/4	19.00
1 3/4	172,400	7	2 3/4	1 7/8	24.00
2	235,620	8	3 1/4	2 1/4	38.20

TABLE ON OPEN SOCKETS

Size Socket and Diameter of Rope in Inches	Circumference of Rope in Inches	Diam. of Pin that may be inserted in Socket Loop in Inches	Length of Basket in Inches	Length Over All in Inches	Approximate Weight in Pounds
2 1/4	7 1/8				
2	6 1/4				
1 3/4	5 1/2				
1 5/8	5				
1 1/2	4 3/4	2 3/4	5 1/2	12 5/8	18.25
1 3/8	4 1/4	2 3/4	5	11 1/8	16.00
1 1/4	4	2 3/4	5	11 1/8	12.75
1 1/8	3 1/2	2 1/4	4 1/2	10 1/2	10.50
1	3	2 1/4	4 1/2	10 1/2	8.75
7/8	2 3/4	2	4	9 1/4	6.00
3/4	2 1/4	1 3/4	3 3/8	8	3.75
9/16	1 3/4	1 5/16	2 3/4	6	1.85
1/2	1 1/2	1 5/16	2 3/4	6	1.50
7/16	1 1/4	1 1/8	2 1/2	5 1/4	1.25
3/8	1 1/8	1 1/8	2 1/2	5 1/4	.87
5/16	1	15/16	1 5/8	3 3/4	.65
1/4	3/4	15/16	1 5/8	3 3/4	.44

TABLE ON CLOSED SOCKETS

Size Socket and Diameter of Rope in Inches	Circumference of Rope in Inches	Width Between Jaws in Inches	Diameter of Pin in Inches	Length of Basket in Inches	Length Over All in Inches	Approximate Weight in Pounds
2 3/4	7 1/8	3 3/4	4	9 1/4	22	120
2	6 1/4	3 1/2	3 3/4	8 1/4	20	98
1 3/4	5	2 7/16	2 1/4	6 1/8	13 5/8	45
1 1/2	4 3/4	2 7/16	2 1/4	5 1/2	13	30
1 3/8	4 1/4	2 1/8	1 7/8	5	11 1/2	24
1 1/4	4	2 1/8	1 7/8	5	11 1/2	18.5
1 1/8	3 1/2	1 7/8	1 5/8	4 1/2	10	15.5
1	3	1 7/8	1 5/8	4 1/2	10	12.75
7/8	2 3/4	1 9/16	1 1/4	4	8 7/8	8.00
3/4	2 1/4	1 5/16	1 1/2	3 3/8	7 3/8	5.25
5/8	2	1 1/8	1	3	6 3/4	3.87
9/16	1 3/4	15/16	7/8	2 3/4	6	3.00
1/2	1 1/2	15/16	7/8	2 3/4	6	2.25
7/16	1 1/4	7/8	7/8	2 1/2	5 1/2	1.75
3/8	1 1/8	7/8	5/8	2 1/2	5 1/2	1.25
5/16	1	11/16	1/2	1 5/8	3 1/2	.95
1/4	3/4	11/16	1/2	1 5/8	3 1/2	.95

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HAZARD MFG. COMPANY

WILKES-BARRE, PA

NEW YORK	PITTSBURGH	CHICAGO	DENVER	BIRMINGHAM
533 Canal Street	1st Nat'l Bank Building	552 W. Adams Street	1415 Wazee St.	1701 First Ave.

Iron and Steel Wire Rope

"MADE FOR USERS WHO WANT THE BEST"

Products

Wire Rope, made of Iron, Cast Steel, Extra Strong Steel, or Plow Steel; Galvanized Strand; Hand Forged Wire Rope Fittings.

Material and Workmanship

HAZARD Wire Ropes, Galvanized Strand and Fittings have stood the test of time. Made in the heart of the Anthracite District of Pennsylvania, they have for three-quarters of a century kept faith with those consumers who demand the best, and who put quality and service above price. They are made by skilled workmen on modern machines, and of the best materials obtainable. HAZARD Products represent the last word in Wire Rope construction for every purpose.

Maximum output and safety demand the use of only the highest grade Ropes. Since 1848 every effort of the HAZARD MANUFACTURING COMPANY has been exerted to maintain the reputation of the Ropes that make this maximum possible.

Hazard Hoisting Rope, 6 Strands, 19 Wires Each

HAZARD Cast Steel Wire Rope

Made from the best quality of cast steel obtainable for Wire Rope use. It is unexcelled because the material and workmanship entering into its construction are the best. The HAZARD MANUFACTURING COMPANY has never allowed competition to force down the quality of its product.

HAZARD Plough Steel Wire Rope

Made from the highest quality Plough Steel that can be obtained, these Ropes have a breaking strength approximately 30 per cent greater than Cast Steel. The rods are tempered and converted into Wire in our own mills, and every requisite quality for hardness, toughness and ability to resist wear is built into HAZARD Plough Steel Wire Ropes by skilled workmen under expert supervision. They stand for absolute fidelity to the best standards of construction and material.

HAZARD Extra Galvanized Special Strength Strand

Made in three grades of strength and quality; Siemens-Martin Steel, High Strength and Extra High Strength, each grade representing the best Galvanized Strand that can be made in its class.

Hazard Haulage Rope, 6 Strands, 7 Wires Each

It is sold by special list with **guaranteed weights and strains,** and meets all requirements of the A. T. & T. Co., Western Union and Postal Telegraph Companies' specifications for galvanizing.

HAZARD Hand Forged Wire Rope Fittings

Are made to meet the demand for Wire Rope Fittings which are absolutely reliable.

These fittings are made of the finest quality of Triple Refined Iron, in our own blacksmith shop. They are made extra heavy and of proper dimensions to develop the maximum breaking efficiency of the Wire Rope with which they are designed to be used.

Service Men

A HAZARD Service Man will gladly call and suggest possible improvements in operating conditions or a change in type of Rope for better efficiency and economy.

Catalogue

A catalogue and price list, giving full information as to breaking strains, safe working loads, etc., will be furnished on request.

(See Page 270 on Hazard Wire and Cables.)

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MACWHYTE COMPANY

Main Office and Works:
KENOSHA, WIS.

BRANCH OFFICES
Chicago Portland Pittsburgh
Seattle

Manufacturers of
Wire Rope of Every Description

Sole Makers
PATENT "KILINDO" NON-ROTATING WIRE ROPE
MONARCH WHYTE STRAND WIRE ROPE
MONARCH MINE CAR HITCHINGS

TRADE MARK REGISTERED.

TRADE MARK REGISTERED.

Products

Wire Rope, Sockets, Hooks, Thimbles, Clips, Turnbuckles, Sheaves, Blocks, Monarch Mine Car Hitchings, Manila Rope, Tramways.

Monarch "Whyte" Strand Wire Rope.

This is the highest grade rope manufactured. It is made from wire having a tensile strength of 125 tons to the square inch. It is uniform and dependable. The wire before entering the rope is subjected to stringent tests and unless our high standards have been complied with, the wire is rejected. In the manufacture of this rope great care is exercised. The lay of the wires in the strands as well as the strands themselves are perfectly proportioned so as to give each wire an equal portion of the working load. The core is number one hard laid Manila rope, which prevents the rope from pulling in and distorting its lays when subjected to severe strains. This rope is made in various constructions to suit working conditions. It is an absolutely safe rope, incomparable in wearing quality to any other cable on the market and is strong, durable and tough.

Patent Kilindo Non-Rotating Wire Rope

This rope is manufactured by us under a patent issued to George S. Whyte. Kilindo Non-Rotating Rope is exactly what its name implies. It does not rotate or spin when hoisting a loose load. It is, therefore, especially adapted for shaft sinking purposes, and it is also especially desirable to use this rope wherever a non-spinning rope is needed.

The word "Kilindo" is a combination of Greek words meaning "almost round." This brand of rope has a much larger wearing surface than the ordinary six strand rope.—About 200%.

We manufacture Kilindo in all grades such as "Monarch" steel, Plough steel, Mild Plough Cast steel and Swedes iron.

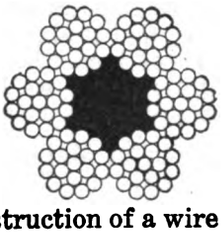
Style No. 1—For Vertical Draw Bar.

Style No. 2—For Horizontal Draw Bar.

MacWhyte Plow Steel Wire Rope

A rope of superior merit, built for mining service where conditions are difficult. Made in various constructions to suit conditions.

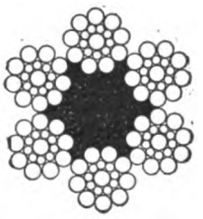
This illustration shows our Standard Hoisting Wire Rope, which is composed of six strands of nineteen wires each, laid around a hemp center, making a total of 114 wires. It is the most common rope used for hoisting purposes and where sheaves are built to accommodate it, it is the most practical rope to use.



This illustration shows the construction of a wire rope usually termed haulage, transmission or standing wire rope. It is composed of six strands of seven wires each, laid around a hemp center, making a total of 42 wires. It is constructed in various grades of iron and steel, which grades are suited to different working conditions. These ropes should never be operated over small drums or sheaves, the wires being too coarse.

Seale Patent Wire Rope

This is a rope composed of six strands of nineteen wires each laid around a hemp core. Each strand is composed of nine large outer wires, nine small inner wires and one large center wire, as shown in the adjoining cut. By this method of construction a rope is produced which is almost as flexible as a standard nineteen-wire rope, in which all the wires in each strand are the same size. but of greater durability in any service where the rope is exposed to unusual abrasion.



Monarch Mine Car Hitchings

SIMPLE—Hitchings proper consists of male and female parts, links and shackles. No screws nuts, springs or washers to become loose or lost.

PERMANENT—Forming a part of the car always present and ready. Not affected by water or weather.

ADAPTABLE—Can be used on any haulage system—electric, rope, mule, steam—and on any grade.

SPEEDY—Only two working parts to attach. Easy to couple and uncouple increases output of mine.

SAFE—Once coupled, they remain coupled until operator knowingly and willingly uncouples them.

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A. LESCHEN & SONS ROPE CO.

ST. LOUIS, U. S. A.

Branch Stores:

NEW YORK CHICAGO DENVER SAN FRANCISCO

MANUFACTURERS OF

High Grade Wire Rope for All Purposes—Aerial Wire Rope Tramways

Products

Wire Rope for all purposes, of both special and standard grades and constructions, including the famous HERCULES (Red Strand) Wire Rope, Wire Ropes of both Round and Patent Flattened Strand construction, Locked Wire Ropes and Locked Coil Cables; Wire Rope Blocks, Clips, Thimbles, Sockets and Hooks, Wire Rope Lubricants; Aerial Wire Rope Tramways.

Design and Workmanship

Every process in the manufacture of Leschen Wire Rope is according to our own exclusive methods, and is accompanied by exacting tests and rigid inspections. Each rope is made to conform to the design that we have found from experience to be best for the particular work the rope is to perform.

Kinds of Material

Leschen Wire Ropes for mining are furnished in the following grades: HERCULES (Red Strand) Wire Rope, Special Steel, Plow Steel and Cast Steel.

"HERCULES" Wire Rope
(Reg. U. S. Pat. Off.)

This is a rope of the very highest quality. It is the correct combination of strength, elasticity, toughness and flexibility for maximum service. It is the best that can be bought at any price, and because of its durability it is the most economical rope for heavy work that can be obtained. It is recommended for mine hoisting and hauling, steam shovels, mining machines, etc. HERCULES Wire Rope always has one red strand for identification purposes. It is made in Round and Patent Flattened Strand constructions.

"SPECIAL STEEL"
(Reg. U. S. Pat. Off.)

A grade of rope of but moderate cost, but possessing high efficiency in a wide variety of operating conditions. Its flexibility is equal to lower strength ropes (an uncommon property), consequently it is well suited for work over small drums and sheaves. Its advantages in point of strength, toughness, durability, and general trustworthiness, are exceptional.

Cast Steel

Cast Steel Wire Rope is standard for ordinary work, being of moderately high tensile strength and quite flexible. It works to good advantage over small sheaves and drums. Its use is general where there are no excessive stresses or unusual conditions encountered.

Plow Steel

The tensile strength developed in Plow Steel Wire Rope is high, and this rope is successfully used where heavy work is performed under conditions where sufficiently large drums and sheaves are practicable.

Constructions

Leschen Wire Rope is made in Patent Flattened Strand, Round Strand and Locked Coil constructions.

The Patent Flattened Strand types of wire rope provide additional wearing surface and greater strength. They are especially recommended for mine hoisting, hauling, steam shovels, and for use on Aerial Wire Rope Tramways.

Locked Coil Cable is an ideal rope for track cable on Aerial Wire Rope Tramways. Its smooth surface minimizes friction and reduces wear.

Mine Hoisting Wire Ropes

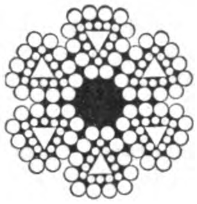

Fig. 1

Fig. 1
Patent Flattened Strand
(6x25)

Fig. 2
Round Strand
(6x19)

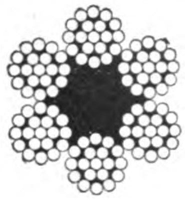

Fig. 2

PATENT FLATTENED STRAND CONSTRUCTIONS

"HERCULES" (RED STRAND) WIRE ROPE
6 Strands of 25 Wires Each (Fig. 1)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
¾	.37½	29.	5.8	1.00	4.
⅞	.49	39.	7.8	1.38	4.50
1	.60	50.	10.0	1.80	5.
1⅛	.71	62.	12.4	2.30	6.
1¼	.89	76.	15.2	2.80	7.
1⅜	1.12	92.	18.4	3.45	7.50
1½	1.37	108.	21.6	4.00	8.

"SPECIAL STEEL" WIRE ROPE
6 Strands of 25 Wires Each (Fig. 1)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
¾	.30	22.2	4.44	1.00	3.
⅞	.38	29.	5.8	1.38	3.50
1	.48	37.	7.4	1.80	4.
1⅛	.59	47.	9.4	2.30	4.50
1¼	.70	58.	11.6	2.80	5.
1⅜	.90	70.	14.	3.45	5.50
1½	1.05	80.	16.	4.00	5.75

ROUND STRAND CONSTRUCTIONS

"HERCULES" (RED STRAND) WIRE ROPE
6 Strands of 19 Wires Each (Fig. 2)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
¾	.31	26.3	5.3	.89	3.
⅞	.39	35.	7.	1.20	3.50
1	.50	45.	9.	1.58	4.
1⅛	.62	56.	11.	2.	4.50
1¼	.75	69.	14.	2.45	5.
1⅜	.90	84.	17.	3.	5.50
1½	1.10	98.	20.	3.55	6.

"SPECIAL STEEL" WIRE ROPE
6 Strands of 19 Wires Each (Fig. 2)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
¾	.22	20.2	4.04	.89	3.
⅞	.29	26.	5.20	1.20	3.5
1	.37	34.	6.80	1.58	4.
1⅛	.46	43.	8.6	2.	4.5
1¼	.56	53.	10.6	2.45	5.
1⅜	.68	64.	12.8	3.	5.5
1½	.80	73.	14.6	3.55	6.

CAST STEEL WIRE ROPE
6 Strands of 19 Wires Each (Fig. 2)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
¾	.19	17.5	3.5	.89	3.
⅞	.24	23.	4.6	1.20	3.5
1	.31	30.	6.	1.58	4.
1⅛	.38	38.	7.6	2.	4.5
1¼	.46	47.	9.4	2.45	5.
1⅜	.56	56.	11.2	3.00	5.5
1½	.66	64.	12.8	3.55	6.

PLOW STEEL WIRE ROPE
6 Strands of 19 Wires Each (Fig. 2)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
¾	.26	23.	4.6	.89	3.
⅞	.34	29.	5.8	1.20	3.5
1	.43	38.	7.6	1.58	4.
1⅛	.54	47.	9.4	2.	4.5
1¼	.65	58.	12.	2.45	5.
1⅜	.79	72.	14.	3.	5.5
1½	.93	82.	16.	3.55	6.

If your work requires a rope of a size not shown herein, write us for data. We make hoisting ropes in all used sizes.

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Wire Rope for Mine Haulage, Guys, Etc.

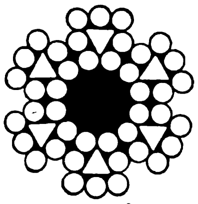


Fig. 3

Fig. 3
Patent Flattened
Strand
6x8

Fig. 4
Round Strand
6x7

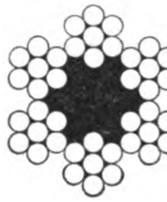


Fig. 4

PATENT FLATTENED STRAND CONSTRUCTIONS

"HERCULES" (RED STRAND) WIRE ROPE
6 Strands of 8 Wires Each (Fig. 3)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.16¼	11.9	2.38	.45	3.75
⅝	.25	19.	3.8	.72	4.50
¾	.35	27.	5.4	1.00	5.25
⅞	.44	36.	7.2	1.38	6.
1	.58	46.	9.2	1.80	6.75
1⅛	.70	56.	11.2	2.30	8.

"SPECIAL STEEL" WIRE ROPE
6 Strands of 8 Wires Each (Fig. 3)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.14	9.6	1.92	.45	2.50
⅝	.18	15.7	3.14	.72	3.50
¾	.27	22.7	4.54	1.00	4.50
⅞	.35	30.	6.0	1.38	5.
1	.45	38.	7.6	1.80	5.75
1⅛	.54	46.	9.2	2.30	6.25

CAST STEEL WIRE ROPE
6 Strands of 8 Wires Each (Fig. 3)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.10	8.3	1.66	.45	2.50
⅝	.14	14.	2.8	.72	3.50
¾	.20½	20.	4.	1.00	4.50
⅞	.27½	26.	5.2	1.38	5.
1	.35	34.	6.8	1.80	5.75
1⅛	.45	40.	8.	2.30	6.25

ROUND STRAND CONSTRUCTIONS

"HERCULES" (RED STRAND) WIRE ROPE
6 Strands of 7 Wires Each (Fig. 4)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.13½	11.	2.2	.39	3.50
9/16	.17	13.	2.6	.50	4.0
⅝	.20½	17.50	3.5	.62	4.50
11/16	.24½	20.	4.	.75	4.75
¾	.28½	25.	5.	.89	5.
⅞	.37	33.	6.6	1.20	6.
1	.48	42.	8.4	1.58	7.
1⅛	.58	52.	10.	2.	8.

"SPECIAL STEEL" WIRE ROPE
6 Strands of 7 Wires Each (Fig. 4)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.09½	8.85	1.8	.39	3.50
9/16	.12	11.	2.2	.50	4.
⅝	.14¼	14.5	2.9	.62	4.50
11/16	.17	16.7	3.3	.75	4.75
¾	.20	21.	4.2	.89	5.
⅞	.27	28.	5.6	1.20	6.
1	.35	35.	7.	1.58	7.
1⅛	.44	43.	8.6	2.	8.

CAST STEEL WIRE ROPE
6 Strands of 7 Wires Each (Fig. 4)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.08	7.7	1.5	.39	3.50
9/16	.10	10.	2.	.50	4.
⅝	.12	13.	2.6	.62	4.50
11/16	.14½	15.4	3.1	.75	4.75
¾	.17	18.6	3.7	.89	5.
⅞	.22½	24.	4.8	1.20	6.
1	.29	31.	6.2	1.58	7.
1⅛	.36	37.	7.4	2.	8.

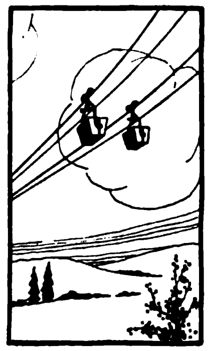
PLOW STEEL WIRE ROPE
6 Strands of 7 Wires Each (Fig. 4)

Diam. in Inches	List Price per Foot	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Approximate Weight per Foot	Diam. in Ft. of Drum or Sheave Advised
½	.11½	10.	2.	.39	3.50
9/16	.14½	12.	2.4	.50	4.
⅝	.17½	16.	3.2	.62	4.50
11/16	.21	18.	3.6	.75	4.75
¾	.24½	23.	4.6	.89	5.
⅞	.32	31.	6.2	1.20	6.
1	.41	38.	7.6	1.58	7.
1⅛	.51	47.	9.4	2.	8.

If your work requires a rope of a size not shown herein, write us for data. We make haulage ropes in all used sizes.

Leschen Aerial Wire Rope Tramways

The economical transportation of coal, ore and waste from mines by means of Leschen Aerial Wire Rope Tramways is not a matter of conjecture or theory, but a fact established by the actual operation of numerous installations.



They operate successfully over any kind of country. They cross hills and rivers without expensive grading or bridge work. They are not affected by weather conditions.

They are economical to operate both as to power and labor; oftentimes they can be run by gravity.

We manufacture Aerial Tramways in various systems, and are therefore able to furnish that type of Tramway best suited to any existing condition.

Our Engineering Department will be glad to advise with you as to the practicability of an Aerial Tramway for your particular work and to submit you an estimate, if you will furnish us information as suggested below:

(1) Give length of tramway in straight line. If horizontal curves cannot be avoided, give angle of each curve.

(2) Give difference in elevation between terminal points, and state which terminal is at the higher elevation. If possible, send rough sketch showing profile of ground.

(3) State number and capacities of bins desired at each terminal.

(4) State material to be handled.

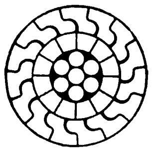
(5) Give weight per cubic foot of material in the form it will be carried over the tramway.

(6) State how many tons (2000 lbs.) you wish to transport per hour.

(7) A profile made from an accurate survey is required in addition to above data, if a final and definite price is wanted.

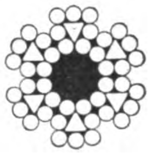
The details, quality, workmanship, design and manufacture of all Leschen Tramways are the outcome of many years of practical experience in this class of work.

Wire Ropes for Aerial Wire Rope Tramways



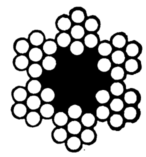
Locked Coil

Track Cables

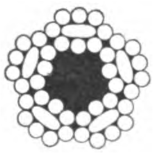


Patent Flattened Strand

Track Cables



Round Strand



Patent Flattened Strand

Traction Cables

Round Strand

We will be glad to supply any one interested with full data concerning the different types of Tramway Rope above illustrated, or make a rope recommendation for any particular conditions.

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JOHN A. ROEBLING'S SONS COMPANY

Main Office: TRENTON, N. J.

Works: TRENTON, N. J., and ROEBLING, N. J.

NEW YORK—117-119-121 Liberty St.
BOSTON—93-95 Pearl St.
CHICAGO—165 West Lake St.
PHILADELPHIA—223 Arch St.
PITTSBURGH—Sandusky and Robinson Sts., N. S.
CLEVELAND—701 St. Clair Ave., N. E.
ATLANTA—69 Walton St.
SAN FRANCISCO—624-46 Folsom St.
LOS ANGELES—216 S. Alameda St.
PORTLAND ORE.—487 Lovejoy St.
SEATTLE—900 First Ave., South

Manufacturers of

Wire Rope For Mining

And All Other Purposes For Which Wire Rope Is Used

Products

Iron, Steel and Copper Wire Rope and Wire, Telephone Wire, Trolley Wire, Insulated Wires and Cables; manufacturers of a full line of wire rope fittings, such as Sockets, Clips, Clamps, Hooks, Sheaves, Thimbles, Turnbuckles, Slings, Alligator Wrenches, Track Rollers, etc.

General

The first wire rope used in this country was a Roebling rope. Since its production the manufacture of wire rope has never been interrupted, and as the demand has increased the facilities for production have expanded so that the Roebling Company now has three works (two at Trenton, N. J., and one at Roebling, N. J.), and has also numerous branches in different parts of the country.

Service

Our Engineering Department specializes in the study of unusual wire rope conditions and will gladly make recommendations if full operating data is submitted. We also specialize in designing and constructing Suspension Bridges, Cableways, etc.

Quality

All steel for Roebling Wire Rope is manufactured at our works. We therefore control all processes of manufacture from ore to finished products. Uniformity of products is therefore assured.

Several grades of steel are necessary to meet wire rope requirements, but for Mining purposes the four grades described below are used.

Blue Center Steel Rope

Recent advances in the manufacture of steel have made possible the production of a grade particularly well adapted for rope wire, and excelling all others in strength and toughness.

Where conditions are such that the maximum of strength for a given diameter of rope must be obtained, or severe tendencies exist, blue center steel should be specified.

Blue center steel rope is not only well adapted for ropes of unusual size, but it will give the maximum service in the ordinary diameters. The hemp center of Blue Center Steel Rope is colored blue to distinguish it from other grades.

Plow Steel

Up to the time of the production of blue center steel, the strongest and toughest rope was made of plow steel. Rope made of plow steel is used largely for mine hoists and haulages, and on coal hoists, cableways and conveyors.

Extra Strong Cast Steel

Extra Strong Cast Steel Rope occupies an intermediate place between cast steel and plow steel. It can be used to advantage in place of cast steel under conditions suitable for the latter, when it is desired to increase the safety of a rope of given diameter.

Cast Steel

While cast steel does not have the strength per square inch of the other steels referred to above and lacks the resistance to abrasion of plow or blue center steel, conditions often exist where for a given diameter of rope the stress is not beyond the working strength of cast steel, and its wearing qualities are amply sufficient.

In contemplating the selection of a wire rope, if doubt exists as to the grade, we shall be glad to make suggestions on being advised of conditions.

STANDARD CONSTRUCTION

6x19 Hoisting Rope

This construction is used for general Hoisting purposes and is particularly adapted to Shaft Hoist requirements. When severe abrasion is governing factor, increased service is secured by making rope Lang Lay. This construction is also used for slopes and inclines where sheave and drum diameter will not allow the use of 6x7 construction.

8x19 Hoisting Rope

This construction gives greater flexibility than the 6x19 and therefore can be used with sheaves and drums of small diameter, providing loads are proportionately less; strength of rope being about three-quarters that of 6x19 construction.

It is used extensively on Coal unloading towers, also Coal and Ore Bridges.

6x37 Hoisting Rope

When sheaves are small and high operating tension is necessary, this construction should be used in preference to 8x19.

6x7 Construction

Used extensively on slopes and inclines equipped with large sheaves and drums. On installations where abrasion is governing factor, rope should be made Lang Lay.

Modifications of above constructions are sometimes necessary to give maximum rope service. Our Engineering Department will advise you fully as to rope requirements upon receipt of full operating conditions.

If interested, we will gladly send you any of the following publications:

Wire Rope Catalogue
The Splicing of Wire Rope
Wire Rope Sockets
Wire Rope Clips
How to Order Wire Rope

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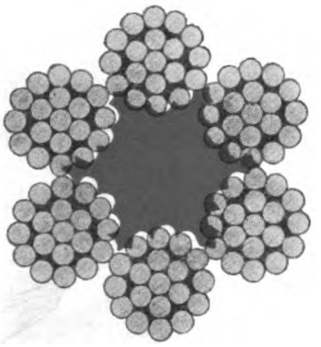
COMPARATIVE BREAKING STRENGTHS OF WIRE ROPE PER GIVEN DIAMETER IN TONS OF 2000 LBS.

Roebling Standard Hoisting Rope (6x19)

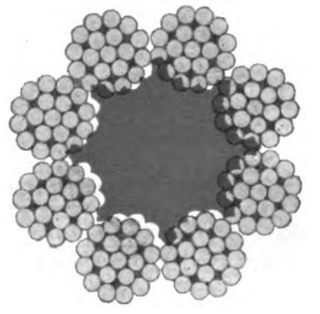
Diameter in Inches	APPROXIMATE STRENGTH				Approximate Weight Per Ft. in Lbs.
	Cast Steel	Extra Strong Cast Steel	Plow Steel	Blue Center Steel	
2¾	211.	243.	275.	315.	11.95
2½	170.	200.	229.	263.	9.85
2¼	133.	160.	186.	210.	8.
2	106.	123.	140.	166.	6.30
1⅞	96.	112.	127.	150.	5.55
1¾	85.	99.	112.	133.	4.85
1⅝	72.	83.	94.	110.	4.15
1½	64.	73.	82.	98.	3.55
1⅜	56.	64.	72.	84.	3.
1¼	47.	53.	58.	69.	2.45
1⅛	38.	43.	47.	56.	2.
1	30.	34.	38.	45.	1.58
⅞	23.	26.	29.	35.	1.2
¾	17.5	20.2	23.	26.3	.89
⅝	12.5	14.	15.5	19.	.62
½	10.	11.2	12.3	14.5	.50
⅜	8.4	9.2	10.	12.1	.39
⅜	6.5	7.25	8.	9.4	.30
¼	4.8	5.30	5.75	6.75	.22
¼	3.1	3.50	3.8	4.50	.15
⅛	2.2	2.43	2.65	3.15	.10



Roebling 6x19 Blue Center Steel Rope

Roebling Extra Pliable Hoisting Rope (8x19)

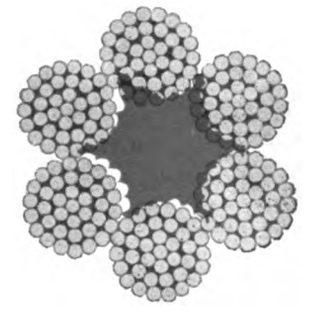
Diameter in Inches	APPROXIMATE STRENGTH				Approximate Weight Per Ft. in Lbs.
	Cast Steel	Extra Strong Cast Steel	Plow Steel	Blue Center Steel	
1½	58.	66.	74.	80.	3.19
1⅜	51.	57.	64.	68.	2.70
1¼	42.	47.	52.	56.	2.20
1⅛	34.	38.	43.	46.	1.80
1	26.	29.7	33.	36.	1.42
⅞	20.	23.	26.	28.	1.08
¾	15.3	17.6	20.	22.	.80
⅝	10.9	12.4	14.	15.	.56
½	8.7	10.1	11.6	12.	.45
½	7.3	8.	8.7	9.5	.35
⅜	5.7	6.3	6.9	....	.27
⅜	4.2	4.66	5.12	....	.20
¼	2.75	3.05	3.35	....	.13
⅛	1.8	2.02	2.25	....	.09



Roebling 8x19 Blue Center Steel Rope

Roebling Extra Pliable Hoisting Rope (6x37)

Diameter in Inches	APPROXIMATE STRENGTH				Approximate Weight Per Ft. in Lbs.
	Cast Steel	Extra Strong Cast Steel	Plow Steel	Blue Center Steel	
2¾	200.	233.	265.	278.	11.95
2½	160.	187.	214.	225.	9.85
2¼	125.	150.	175.	184.	8.
2	105.	117.	130.	137.	6.30
1¾	84.	95.	108.	113.	4.85
1⅝	71.	79.	90.	95.	4.15
1½	63.	71.	80.	84.	3.55
1⅜	55.	61.	68.	71.	3.
1¼	45.	50.	55.	58.	2.45
1⅛	34.	39.	44.	46.	2.
1	29.	32.	35.	37.	1.58
⅞	22.	25.	27.	29.	1.20
¾	17.5	19.	21.	23.	.89
⅝	11.2	12.6	14.	16.	.62
½	9.5	10.5	11.5	12.5	.50
½	7.25	8.25	9.25	9.75	.39
⅜	5.5	6.35	7.2	7.50	.30
⅜	4.2	4.65	5.1	5.30	.22



Roebling 6x37 Blue Center Steel Rope

Roebling Standard Coarse Laid Rope (6x7)

Diameter in Inches	APPROXIMATE STRENGTH				Approximate Weight Per Ft. in Lbs.
	Cast Steel	Extra Strong Cast Steel	Plow Steel	Blue Center Steel	
1¼	63.	73.	82.	90.	3.55
1⅛	53.	63.	72.	79.	3.
1¼	46.	54.	60.	67.	2.45
1⅛	37.	43.	47.	52.	2.
1	31.	35.	38.	42.	1.58
⅞	24.	28.	31.	33.	1.20
¾	18.6	21.	23.	25.	.89
⅝	15.4	16.7	18.	20.	.75
½	13.	14.5	16.	17.5	.62
½	10.	11.	12.	13.	.50
⅜	7.7	8.85	10.	11.	.39
⅜	5.5	6.25	7.	7.75	.30
¼	4.6	5.25	5.9	6.5	.22
¼	3.5	3.95	4.4	....	.15
⅛	2.5	2.95	3.4	....	.125

Roebling 6x7 Blue Center Steel Rope

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WILLIAMSPORT WIRE ROPE CO.

WILLIAMSPORT, PENNA.

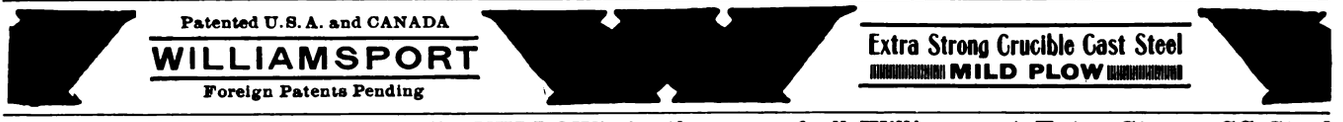
Wire Rope and Cables

Williamsport inaugurates an innovation in Wire Rope construction, by their patented Telfax Tape Marker, which absolutely distinguishes each grade of wire rope, thus enabling the consumer to determine instantly the grade of wire rope they get without resorting to expensive engineering or laboratory tests. It is a protection all will welcome.

This marker appears in all grades of Williamsport wire rope manufactured since November 1, 1921.

The above Telfax Tape appears in the core of all Williamsport Improved Plow Steel Wire Rope.

The above Telfax Tape appears (in GREEN) in the core of all Williamsport Plow Steel Wire Rope.



The above Telfax Tape appears (in YELLOW) in the core of all Williamsport Extra Strong CC Steel Wire Rope.

The above Telfax Tape appears (in RED) in the core of all Williamsport Crucible Cast Steel Wire Rope.

The above Telfax Tape appears (in BROWN) in the core of all Williamsport Mild Steel Elevator Rope.

The above Telfax Tape appears (in BLACK) in the core of all Williamsport Iron Wire Rope.

SEND FOR THE ABOVE CHART IN FULL COLORS

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Products

Wire Rope of all kinds and constructions for all purposes; Clamps; Turnbuckles; Clips; Sheaves; Hooks and Sockets; a complete line of Hoisting, Haulage and Transmission Wire Ropes.

Design—Workmanship—Quality

Built in a model wire rope plant with the very latest, special machinery. Each operation subjected to most rigid tests, from the rods to the ropes.

We draw all our wire and have testing apparatus for the smallest diameters and others that can test to rupture ropes of any diameter.

Grades—Construction

You will find the grades of Williamsport wire rope featured upon the opposite page, introducing at the same time the patented Telfax marking device which, since November 1, 1921, has been built into the entire length of the core of every rope made by us.

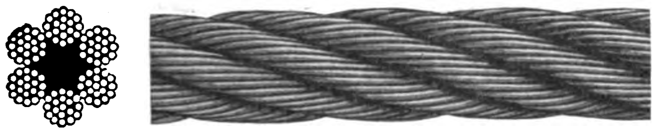
There are innumerable constructions of wire ropes, perhaps more with Williamsport than others, because we make so much rope "to order," as specified, through the co-operation of our service and engineering departments.

Our general catalog will give those interested some very desirable data on Modern Wire Rope as made by Williamsport.

THE FOLLOWING ARE MOST FREQUENTLY USED IN MINING OPERATIONS

Standard Flexible Hoisting Rope

Composed of 6 strands of 19 wires each around a hemp center.



Standard Hoisting Rope

Made of Crucible Cast Steel, Extra Strong Crucible Cast Steel, Plow Steel and Improved Plow Steel wire. All of the wire which enters into our hoisting rope is drawn in our modern wire mill from especially selected rods having chemical and physical qualities best suited for the requirements of each individual case.

CRUCIBLE CAST STEEL
(See Our General Catalog for Other Lists)

List price per foot	Diameter in inches	Approximate weight per foot	Approximate strength in tons of 2000 pounds	Proper working load in tons of 2000 pounds	Diameter of drum or sheave in ft. advised
$0.90	1¾	4.85	85	17	7
.77	1⅝	4.15	72	14.4	6.5
.66	1½	3.55	64	12.8	6
.56	1⅜	3	56	11.2	5.5
.46	1¼	2.45	47	9.4	5
.38	1⅛	2	38	7.6	4.5
.31	1	1.58	30	6	4
.24	⅞	1.20	23	4.6	3.5
.19	¾	.89	17.5	3.5	3
.14	⅝	.62	12.5	2.5	2.5
.12	9/16	.50	10	2	2.25
.11	½	.39	8.4	1.68	2
.10	7/16	.30	6.5	1.30	1.75
.09½	⅜	.22	4.8	.96	1.50
.09¼	5/16	.15	3.1	.62	1.25
.09	¼	.10	2.2	.44	1

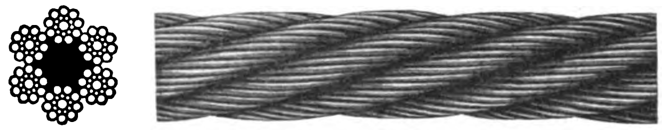
The following list applies to ropes illustrated here →

(Standard Lay) CRUCIBLE CAST STEEL (Lang Lay)
(See Our General Catalog for Other Lists)

List price per foot	Diameter in inches	Approximate weight per foot	Approximate strength in tons of 2000 pounds	Proper working load in tons of 2000 pounds	Diameter of drum or sheave in ft. advised
$0.60	1½	3.55	63	12.6	11
.51	1⅜	3	53	10.6	10
.43	1¼	2.45	46	9.2	9
.36	1⅛	2	37	7.4	8
.29	1	1.58	31	6.2	7
.22½	⅞	1.20	24	4.8	6
.17	¾	.89	18.6	3.7	5
.14½	11/16	.75	15.4	3.1	4¾
.12	⅝	.62	13	2.6	4½
.10	9/16	.50	10	2	4
.08	½	.39	7.7	1.5	3½
.06½	7/16	.30	5.5	1.1	3
.05½	⅜	.22	4.6	.92	2¾
.04½	5/16	.15	3.5	.70	2¼
.04	9/32	.125	2.5	.50	1¾

Seale Lay Rope

Composed of 6 strands of 19 wires each and a hemp center. This rope is recommended for hoisting and haulage purposes where large drums or sheaves are used.

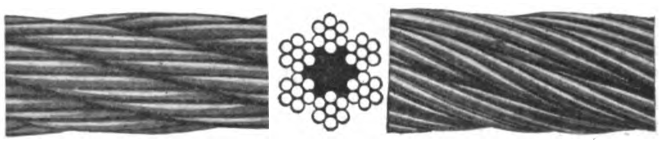


Seale Lay Rope

PLOW STEEL SEALE LAY HOISTING ROPE
(See Our General Catalog for Other Lists)

List price per foot	Diameter in inches	Approximate weight per foot	Approximate strength in tons of 2000 pounds	Proper working load in tons of 2000 pounds	Diameter of drum or sheave in ft. advised
$1.30	1¾	4.85	112	22	7
1.08	1⅝	4.15	94	19	6.5
.93	1½	3.55	82	16	6
.79	1⅜	3	72	14	5.5
.65	1¼	2.45	58	12	5
.54	1⅛	2	47	9.4	4.5
.43	1	1.58	38	7.6	4
.34	⅞	1.20	29	5.8	3.5
.26	¾	.89	23	4.6	3
.19	⅝	.62	15.5	3.1	2.5
.16	9/16	.50	12.3	2.4	2.25
.14	½	.39	10	2	2
.13	7/16	.30	8	1.6	1.75
.12½	⅜	.22	5.75	1.15	1.50
.12¼	5/16	.15	3.8	.76	1.25
.12	¼	.10	2.65	.53	1

We will be glad to send a very desirable Wire Rope record book to all who should have one. Keep a service record book. It pays.



Standard Lay   Lang Lay

Standard Lay Coarse Laid Rope

Composed of 6 strands of 7 wires each around a hemp center. Made of Crucible Cast Steel, Extra Strong Crucible Cast Steel, Plow Steel and Improved Plow Steel. This rope is recommended for Standing Rope, Ferry Rope, Sand Lines, Guys, Rigging and Underground Haulage in Coal Mines.

Lang Lay Coarse Laid Rope

Composed of 6 strands of 7 wires each around a hemp center. Made of Crucible Cast Steel, Extra Strong Crucible Cast Steel, Plow Steel and Improved Plow Steel. This rope has same characteristics as Standard Lay, except the wires and strands are twisted in the same direction.

The data table opposite these descriptions applies to both Standard Lay and Lang Lay Crucible Steel ropes.

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WICKWIRE SPENCER STEEL CORP.

WORCESTER, MASS. BUFFALO, N. Y.

District Offices and Warehouses

BOSTON NEW YORK PHILADELPHIA DETROIT CHICAGO TULSA SAN FRANCISCO

Manufacturers of

Wire Rope for Mining

Products

Wire Drawn from Iron, Steel, Brass, Copper, Bronze, Aluminum; Wire Poultry Netting; Wire and Iron Fencing and Gates; Wire Cloth, Wire Screen Cloth, Wire Lathing; Electrically Welded Wire, Welded Sheathing; Perforated Metals; Wire Rope and Cable; Wire Springs; Wire Forms; Special Manufacturers' Wire, Wire Goods, Ornamental Wire and Iron; Elevator Cabs and Enclosures; Grilles; Office Railings; Flower Bed Guards; Lawn Borders; Trellises; Arches; Riddles; Coal and Sand Screens; Wire Specialties.

Wickwire Wire Ropes

Are made from specially selected materials in a wide variety of types to meet every engineering need.

Grades of Wire Ropes

We furnish all kinds of mining ropes in Crucible Cast Steel, Extra Strong Crucible Cast Steel, Plow Steel and Gray Strand.

Quality

Wickwire Ropes are made from selected wire drawn in our own mills. All processes of manufacture are controlled from the ore to the finished product.

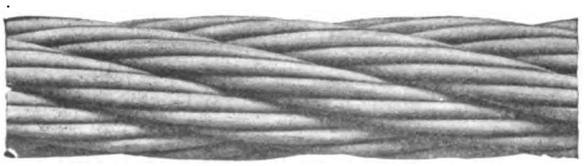
Service

Our Service Department will gladly help you to solve your Wire Rope problems upon receipt of full operation data.

Standard Lay and Lang Lay Ropes

Composed of 6 strands 7 wires to the strand around a hemp center.

Haulage ropes are made either Standard or Lang Lay. In the Lang Lay construction the wires and strands are both laid in the same direction, allowing greater wearing service and giving more flexibility than Standard Lay.



6 Strands—7 Wires to the Strand—1 Hemp Core
Standard Lay Coarse Laid Rope

6x19 Standard Hoisting Rope

This construction is used for general Hoisting purposes and is particularly adapted to Shaft Hoist requirements. When severe abrasion is governing factor, increased service is secured by making rope Lang Lay. This construction is also used for slopes and inclines where sheave and drum diameter will not allow the use of 6x7 construction.

6 Strands—19 Wires to the Strand—1 Hemp Core
Standard Hoisting Rope

Fittings

We furnish a full line of wire rope fittings, such as sockets—both open and closed—hooks, thimbles, turn buckles, clamps, etc.

Comparative Breaking Strengths of Wire Rope Per Given Diameter in Tons of 2000 Lbs.

WICKWIRE STANDARD COARSE LAID ROPE (6x7)

Diameter in Inches	APPROXIMATE STRENGTH				Approx. Weight Per Ft. in Lbs.
	Cast Steel	Extra Strong Cast Steel	Plow Steel	Gray Strand	
1½	63.	73.	82.	90.	3.55
1⅜	53.	63.	72.	79.	3.
1¼	46.	54.	60.	67.	2.45
1⅛	37.	43.	47.	52.	2.
1	31.	35.	38.	42.	1.58
⅞	24.	28.	31.	33.	1.20
¾	18.6	21.	23.	25.	.89
11/16	15.4	16.7	18.	20.	.75
⅝	13.	14.5	16.	17.5	.62
9/16	10.	11.	12.	13.	.50
½	7.7	8.85	10.	11.	.39
7/16	5.5	6.25	7.	7.75	.30
⅜	4.6	5.25	5.9	6.5	.22
5/16	3.5	3.95	4.4	....	.15
¼	2.5	2.95	3.4	....	.125

WICKWIRE STANDARD HOISTING ROPE (6x19)

Diameter in Inches	APPROXIMATE STRENGTH				Approx. Weight Per Ft. in Lbs.
	Cast Steel	Extra Strong Cast Steel	Plow Steel	Gray Strand	
2¾	211.	243.	275.	315.	11.95
2½	170.	200.	229.	263.	9.85
2¼	133.	160.	186.	210.	8.
2	106.	123.	140.	166.	6.30
1⅞	96.	112.	127.	150.	5.55
1¾	85.	99.	112.	133.	4.85
1⅝	72.	83.	94.	110.	4.15
1½	64.	73.	82.	98.	3.55
1⅜	56.	64.	72.	84.	3.
1¼	47.	53.	58.	69.	2.45
1⅛	38.	43.	47.	56.	2.
1	30.	34.	38.	45.	1.58
⅞	23.	26.	29.	35.	1.2
¾	17.5	20.2	23.	26.3	.89
⅝	12.5	14.	15.5	19.	.62
9/16	10.	11.2	12.3	14.5	.50
½	8.4	9.2	10.	12.1	.39
7/16	6.5	7.25	8.	9.4	.30
⅜	4.8	5.30	5.75	6.75	.22
5/16	3.1	3.50	3.8	4.50	.15
¼	2.2	2.43	2.65	3.15	.10

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THE IRONSIDES COMPANY

The Ironsides Bldg., 395-397 E. Broad St.
COLUMBUS, OHIO, U. S. A.

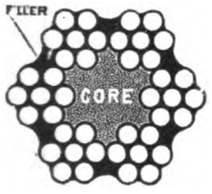
Special Lubricants and Preservatives

Products

Industrial—Wire Rope Filler, Wire Rope Shield, Fibre Rope Shield, Gear Shield, Neck Shield, Cam-Plunger Shield, Belt Shield, Journal Bearing Cup Shield, Paints, Tormay Pit Car Oiler. Automotive—Auto Gear Shield, Tractor Gear Shield, Auto-Tractor Motor Oils.

Ironsides Wire Rope Filler

This material is a lubricant for internally treating ropes as laid up by the manufacturer. Ropes for all purposes: Cable Railways, Hoists, Inclined Planes, Power Transmission, Elevators, etc., are internally lubricated and preserved.



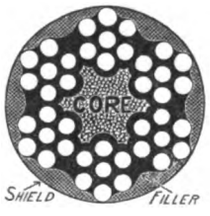
It lubricates between the strands and seals the gutters, making water-soaked and corroded interiors impossible. The lubricant surrounding the core and strands penetrates the core which serves as a reservoir, releasing the preservative as needed.

Contains no destructive acid. The core is lubricated and preserved; the wires adjoining are lubricated and preserved from corrosion; abutting wires between strands are lubricated; each strand is cushioned in lubrication. Ropes so treated are pliable, readily accommodating bends.

Ironsides Wire Rope Filler is used by many of the best wire rope manufacturers. Purchasers by so specifying may have their ropes laid up in this material.

Ironsides Wire Rope Shield

This material is a pliable, tenacious and water-proof lubricant for outside application to ropes. Extensively used throughout mining and industrial districts for lubricating ropes through external application. Contains no destructive acid, lubricates between the wires, lubricates and protects high points of strands. Acid-proof and water-proof, making corroded or water-soaked interiors impossible. Tenaciously holds to rope under severe operating conditions and elastically adjusts itself to bends, likewise preserving grooves of sheaves.



Ironsides Plunger Shield

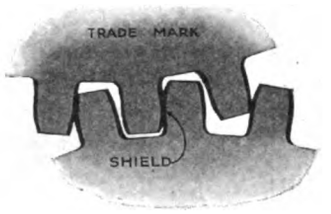
An excellent lubricant for pump plungers and packings. Effectively protects against acid-water attacks. Gives superior results on cams, engine journals, drum and pulley bearings.

Ironsides Belt Shield

A belt dressing of the same typical superiority as all other Ironsides meritorious Shield Products. Effectively softens and makes belt pliable, insuring perfect contact irrespective of climatic conditions, exposure and severe dusty conditions so frequently encountered.

Ironsides Gear Shield

A tenacious, water-proof lubricant for all gearing; the only lubricant that through occasional reapplication maintains lubricated working faces on gear teeth. Being water-proof, no amount of water can remove it from the gear teeth. An appropriate grade for most aggravated dusty conditions tenaciously adheres to gear teeth.



Prevents metallic contact; lessens the noise through lubricated contact; diminishes noise by lubricated backlash; greatly retards wear on all new gearing; arrests excessive wear on worm gearing; reduces expense of replacements.

For electric mine motor gears and pinions, and mining machine gearing, our specially recommended grade can be used in accumulated form in cases. When heavier bodied grades are used on open gearing, apply by pouring lubricant over slowly revolving gears.

Ironsides Auto Gear Shield is a specially appointed grade for the most efficient lubrication of transmissions and rear axle gearing.

Ironsides Neck Shield

An excellent lubricant originally designed for rolling mills in steel and other metal plants, the exceptional merit of which has extended its use to the necks or journals of crushing rolls for ores, dusty and refractory material and cane grinding machinery.

Ironsides Journal Bearing Cup Shield (Cup Grease)

This is another typical Ironsides meritorious Shield Product for journal bearing lubrication as well as for miscellaneous general uses to which cup greases are adapted.

Ironsides Improved Tormay Oiler

This oiler has a central barrel with a plunger, surrounded by an oil reservoir. Openings in barrel, sealed or unsealed, according to the position of the plunger, communicate with oil reservoir. Adjustable stroke of plunger governs quantity of oil forced by each operation. Oiler may be placed in any position without leakage, but should be hung up by handle for its protection.

Primarily constructed for mine car wheels, its use has spread widely to General Machinery, Locomotives, Stationary Engines, Motors, Hoisting Drums, Sheaves, Guides, Slope Rollers, and, in fact, all places where ordinary oil cans are applicable.

Built in four sizes as follows: ½, ¾, 1 and 1½ gallon.

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SECTION IX

Drainage and Pumping

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Aldrich Pump Co., The
Allis-Chalmers Mfg. Co.
American Well Works, The
Aurora Pump & Mfg. Co.
Deming Co., The
Ingersoll-Rand Co.
Jackson, Byron Iron Works
Morris Machine Works.
Worthington Pump and Machinery Corporation.

FOR LIST OF EQUIPMENT USE D IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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Classification of Pumps and Definitions

Pumps may conveniently be classified according to (1) motive power, as steam, electric, compressed air pumps, etc., (2) construction and operation, as duplex pumps, centrifugal pumps, power pumps, etc., and (3) the use to which they are put, as mine pumps, boiler-feed pumps, sinking pumps, deep-well pumps, etc. In order to have a clear understanding of terms which are commonly used in mine drainage, definitions will now be given of the various names by which pumps are known.

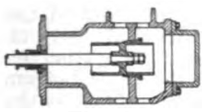

Fig. 9. Plunger Pump.

The plunger pump is so named from the solid rod, cylindrical in section, which puts the water into motion by displacing a volume equal to the part which is thrust into the water end. See Figs. 9 and 13. The plunger pump is the one generally used for boiler feeding.

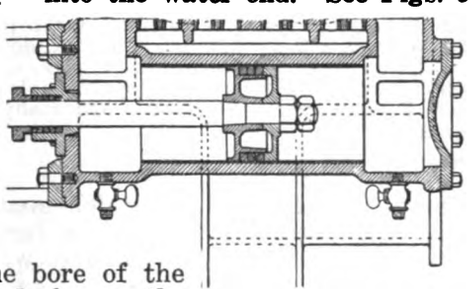

Fig. 10. Piston Pump.

The piston pump uses a disc which closely fits the bore of the water end and forces the water before it. See Fig. 10.

The bucket is a piston containing one or more openings provided with valves which permit the water to pass through at the proper time. See Fig. 11.

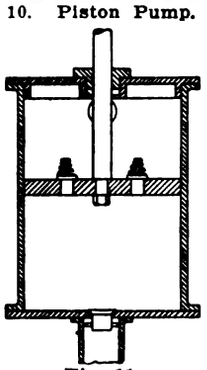

Fig. 11. Bucket Pump.

The stroke of a pump is the distance the piston or plunger travels within the water end. Pumps with 6-inch stroke should never be run over 50 feet per minute; 10-inch stroke not over 60 feet; 12 inches not over 75 feet; 15 inches not over 90 feet; 24 inches not over 110 feet. These figures are intended for simple pumps only. A compound pump can always be safely run from 10 to 15 per cent. higher in piston speed than a simple pump. These are the maximum speeds for direct-acting pumping machinery and should not be exceeded for safe operation. If run slower packing and repairs will be saved.

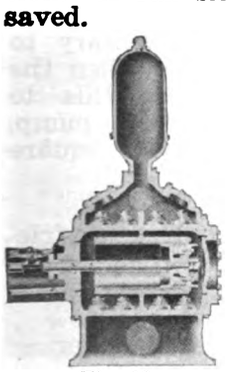

Fig. 12. Double-acting Piston Pump.

Single-acting pumps are those which discharge water while the piston is traveling in one direction. See Fig. 11. Bucket pumps and many plunger power pumps are types of this class.

Double-acting pumps are those which discharge water on both strokes of the engine. Piston pumps are good examples of these. See Fig. 12.

Direct-acting pumps are those in which the steam and water pistons are attached to opposite ends of the same piston rod. Steam driven pumps are examples of these and will be found in large numbers in the Catalog.

Fly-wheel pumps are direct-acting pumps to which a fly-wheel is attached. This permits the use of steam expansively.

Horizontal pumps are those in which the pump cylinder is horizontal.

Vertical pumps are those in which the pump cylinder is vertical.

Reciprocating pumps are so called because their moving parts travel alternately forward and backward in the same straight line.

Power pumps are those in which the pump proper is driven by means of belts or gearing. See Catalog for examples of these.

Inside-packed pumps include piston and plunger pumps which are packed inside the cylinder. See Figure 13 for illustration of plunger pump.

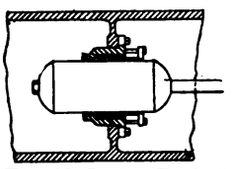

Fig. 13. Inside-Packed Plunger Pump.

Outside-packed pumps are those whose plungers are packed outside the cylinder. Examples showing center-packed and end-packed plunger pumps will be found in the Catalog.

A single pump consists of one steam and one water cylinder. See Catalog.

A duplex pump consists of two single pumps, placed side by side on the same bed plate and having one discharge and one suction pipe in common. In this form the two steam pistons move in opposite directions. The slide valve for one steam cylinder is operated through suitable connections by the piston rod of the opposite cylinder, the D-valve always moving in a direction opposite to that of the piston. See Fig. 14.

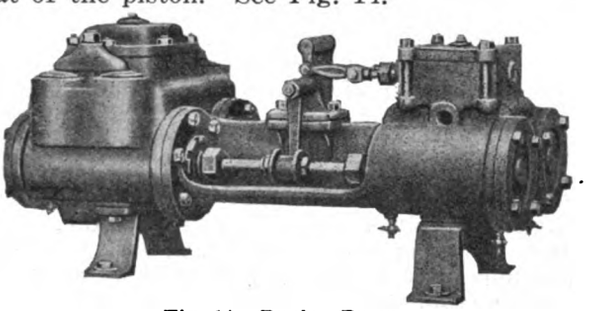

Fig. 14. Duplex Pump.

Triplex pumps are power pumps having three water cylinders.

Multiplex is a term conveniently used to designate power pumps having more than three cylinders, as quadruplex, quintuplex, etc.

A compound steam pump has two steam cylinders of unequal diameter, the steam being passed, after use, from the smaller to the larger where by expanding it continues to do work.

A triple-expansion steam pump has three steam cylinders of unequal diameters, steam from the boilers entering the smallest and passing from here to the intermediate and thence to the largest cylinder. The steam used is thereby expanded in three successive stages.

Condensing steam pumps are those in which the exhaust steam from the low-pressure cylinder is passed to a condenser for the purpose of removing the back pressure of the atmosphere from the exhaust.

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A rotary pump is one which by the rotary motion of its tight-fitting part, or parts, forces the water onward. See Fig. 15. Its capacity varies directly with the speed.

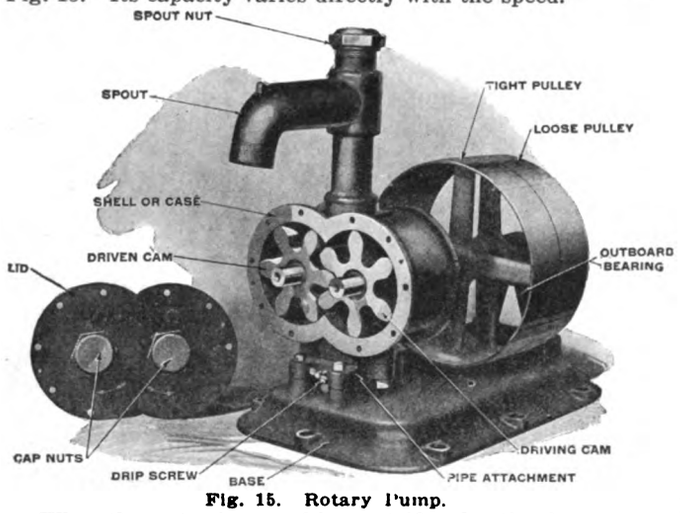

Fig. 15. Rotary Pump.

When the water is moved by centrifugal action by means of a fan wheel operating directly upon the mass of water, it becomes a form of rotary pump known as the centrifugal pump. Unlike the rotary pump, it has tight-fitting parts only at the entrance or eye of the impeller, the rest of the parts having large clearances. See Catalog for illustrations of these.

A volute pump is a centrifugal pump which derives its name from the form of casing or shell and usually refers to single stage, although volute pumps may be connected in series for high heads.

A portable pump is one mounted on a truck, usually having the same gauge as the mine tracks, so that it can be conveniently moved from place to place as needed. They are commonly of the plunger type and driven by electricity.

Gathering, auxiliary, or field pumps are those used for unwatering certain sections or depressions in the mine. In shaft mines they discharge either into the main sump, or into ditches leading thereto.

Turbine pumps are centrifugal pumps which derive their name originally because they were fitted with diffusers or guide vanes outside of the impellers, and thus resemble turbine water wheels, but later any pump with concentric casing is so called.

Main pumps are those used to eject the water out of the mine. In shaft mines they are located at the shaft bottom, or else at some central spot, convenient to the gathering pumps. The discharge line may be run to the shaft bottom and up the shaft, or proceed directly from the pump to the surface through a bore hole.

Because of the methods of construction and operation, pumps are designated as "duplex, piston pumps;" "double-acting, triplex power pumps;" "duplex, double-acting, electric-driven pumps;" "Horizontal, triplex, single-acting, outside-packed, plunger pump;" "duplex, triple-expansion," etc., etc. For illustrations of these and many others see the Catalog.

SIZE AND CAPACITY OF PUMPS

To find the quantity of water delivered by a pump per minute, multiply the displacement of the piston or plunger per stroke in cubic feet by the number of strokes per minute, and by 7.48, the number of gallons in a cubic foot. Expressed as a formula this is,

Formula 1.

$$G=\frac{D^2 \times .7854 \times L \times N \times 7.48}{144}=.0408\ D^2 L\ N$$

Where G=gallons delivered per minute.
D=diameter of the piston or plunger in inches.
L=length of stroke in feet.
N=number of effective strokes per minute.
7.48=number of gallons in one cubic foot of water.

The quantity so found will be the theoretical one and exceeds the actual quantity delivered because of the slip of water past the piston and back through the valves while they are in the act of closing. Furthermore, the length of the stroke varies constantly so that its actual travel will differ somewhat from the calculated travel. The slip in a pump ranges from 2 per cent. to anything above, depending on the tightness of the valves and piston, or the presence of obstructions which prevent the proper closing of the valves. A pump, to be efficient, should not show more than 5 per cent. of slip.

When the quantity of water to be raised per minute is known, the size of the pump required can be calculated by the converse of the above formula

Formula 2.

$$D=\sqrt{\frac{G}{.0408\ L\ N}}=4.95\sqrt{\frac{G}{L\ N}}$$

The theoretical work of the pump will be the weight of the water pumped per minute multiplied by the distance through which it is raised in feet. This product divided by 33,000 will be the horsepower, thus,

Formula 4.

$$HP=\frac{G \times 8.33 \times H}{33{,}000}$$

Where G=gallons of water delivered per minute.
H=total height of lift in feet.
8.33=weight of one gallon of water in pounds.

The pressure of water is a function of its height and may be expressed this,

$$p=.433\ H.$$

Where p=pressure in pounds per square inch.
H=height of lift (head) in feet.
.433=pressure in pounds per square inch due to a head of one foot of water.

Let us assume, for example, that 500 gallons of water per minute are to be pumped to a height of 300 feet. The pressure per square inch on the water piston would be

$$p=.433 \times 300=130\text{-lbs.}$$

Assuming the length of the stroke to be 18 inches, and the number of strokes to be 60 per minute, the area of the water piston may be found by formula (2)

$$D=4.95\sqrt{\frac{G}{L\ N}}=4.95\sqrt{\frac{500}{1\frac{1}{2} \times 60}}=11.7,\ \text{say 12 ins.}$$

The total pressure, P, on the piston is found by multiplying its area in square inches by the unit pressure, thus,

$$P=12^2 \times .7854 \times 130=14702.7\ \text{lbs.}$$

The size of an engine cylinder necessary to overcome this pressure is easily found when the steam pressure is known. Assuming this to be 80 pounds per square inch at the pump, we have, theoretical area of cylinder in square inches $=\frac{14702.7}{80}=183.8$

One-half of this area should be added for frictional resistance,

183.8+91.9=275.7=required area of steam cylinder

$\sqrt{\frac{275.7}{.7854}}=18.7$ inches, say 18 inches diameter

A pump, therefore, having an 18 inch steam cylinder, 12 inch water piston and an 18 inch stroke, or as expressed by the manufacturer, 18" x 12" x 18", will meet the requirements.

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Duty

The duty of a pumping engine has, in the past, been measured by the number of foot pounds of work performed per 100 pounds of coal consumed. With this method any fault in the boilers, boiler setting, chimneys, grates, pre-heating of feed water, etc., was, of necessity, a detriment to the performance of the pumping unit, inasmuch as there was no division of efficiency. In addition, the duty of a pump at a plant using a high grade Pocahontas or New River coal would be considerably higher than where a low grade coal was in use, though the pump performance taken by itself, in the latter case, might, in reality, exceed that of the former. The difference in results might be entirely due to the variation in the heating value of the fuel used, or the inefficiency of the boilers, and therefore furnish no reliable information whereby comparison of pump efficiencies might be made. For the purpose of furnishing comparable data, duty is better defined as the number of foot pounds of useful work done by one thousand pounds of commercially dry steam, or one million British thermal units of heat used by the pump. These values are selected because they approximate the old standard of 100 pounds of coal. The average pound of coal is assumed to give to the water in the boiler about 10,000 B. T. U.'s, which for 100 pounds would total 1,000 B. T. U.'s; likewise it is further assumed that 100 pounds of coal can evaporate 1000 pounds of steam.

A high duty engine is one which gives an exceedingly high number of foot-pounds of work done. The lowest duty is had with the smaller pumps taking steam continuously throughout its stroke; the highest duty is attained by using superheated steam expansively and turning the final exhaust into condensers. The useful work done by the pump is found as follows:*

$$W = Q\,(144p_1 + wh + 144p_2)$$

where W is the total useful work
w is the weight of one cubic foot of water
p_1 is the pressure head in the discharge main in pounds per square inch as determined by a pressure gauge.
p_2 is the vacuum in the suction pipe in pounds per square inch as determined by the gauge or a mercury tube.
h is the distance in feet between the two gauges.
Q is the total number of cubic feet pumped, which may be determined in any one of five ways; first, by displacement calculations; second, by weirs; third, by meters; fourth, by weighing; fifth, by measuring.

The total heat chargeable to the engine is next found, then,

$$\text{Duty} = \frac{\text{Foot-pounds of work done}}{\text{Total No. of heat units consumed}}\ 1{,}000{,}000$$

The efficiency of the centrifugal pump is the ratio between the useful horsepower and the applied horsepower, thus,

$$\text{Efficiency} = \frac{\text{Useful Horsepower}}{\text{Applied Horsepower}}$$

The applied horsepower is determined by means of a dynamometer or calibrated electric motor. The useful horsepower is found according to the equation,

$$\text{U.H.P.} = \frac{w\,Q\,H}{550}$$

where w=weight of one cubic foot of the water pumped.
Q=quantity of water pumped in cubic feet per second.
H=total head, including suction head, discharge head and velocity head.

INFORMATION DESIRED BY MANUFACTURERS

FOR PUMPS

Prices and Estimates on Wood Pipe can be intelligently made only when sufficient information is at hand on which to make recommendations as to the pipe best suited for the purpose intended. When writing for prices, therefore, you should supply as much of the information listed below as is possible for you to procure.

1. Purpose for which pipe will be used.
   A. General .....
   B. Whether the pipe is to be operated under gravity pressure or connected with a pump, turbine or impulse wheel for power development.....
   C. Give type of pump ☐ Single Cylinder ☐ Multiple-Cylinder ☐ Centrifugal
2. Give the inside diameter or diameters of pipe required and the number of lineal feet of each size.....
3. Give the pressure or pressures under which the line will operate (state clearly either in pounds per square inch or head in feet).....
4. Give the quantity of water to be delivered.....
5. Give profile of line if possible.
6. Name point on common carrier to which shipment can be made. .....

If the estimate is to cover construction, you should also advise as to the following:

7. Give average wage for common labor.....
8. Give legal limit on working hours, if any.....
9. When will installation be made?.....
10. Do you want preliminary prices for estimating purposes or do you expect to place your order now?.....

FOR AIR LIFTS

1. Number of wells
2. Depth, feet
3. Depth cased, feet
4. Is casing air tight?
5. Diameter of well, inches
6. Diameter of Standard pipe, inches / Diameter of Casing, inches
7. If Reduced: Diameter, inches / Depth to, feet
8. Further reduction: Diameter, inches / Depth to, feet
9. Character of water strata: (G) Gravel / (S) Sand / (R) Rock
10. Depth to water strata, feet
11. Strainer: Make / Inside diameter, inches / Length, feet / Depth to top, feet
12. Static head (water level not pumping)
13. If well flows (gal. per min.)
14. If well pumped (gal. per min.)
15. Gallons per minute required
16. Pumping head (water level when pumping), feet
17. Kind of pump used: Suction / Deep Well / Air Lift
18. Pump: Diam. cylinder or working bbl., in. / Length of stroke, in. / (Stroke) or (Rev.) per min. / Depth (working bbl. or suction lift) ft.
19. Air lift: Make / Dia. water discharge in well, in. / Length water discharge in well, ft. / Dia. air line in well, in. / Length air line in well, ft. / Starting pressure, lbs. / Running pressure, lbs.
20. Elevation above surface, ft.
21. Horizontal distance well to discharge, ft.
22. Compressor—Make, (Steam) or (Belt), Dia. Air Cyl., Stroke Air Cyl., Speed
23. Working steam pressure, Available boiler H. P.
24. Electric current (A.C.) or (D.C.), Voltage, Phase, Cycle
25. Gas Engine—Make, H. P., Speed
26. Supply sketch showing location of wells, reservoir and compressor.

*Formula from Greene's "Pumping Machinery," which along with Carpenter's "Experimental Engineering" and Kent's "Pocket Book" are recommended to the student for detailed information.

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CENTRIFUGAL VS. RECIPROCATING PUMPS

Requests frequently come in for information about pumping equipment for mines, particularly as to the best type of pumps for particular purposes and for different pumping heads.

The table offered here in response to such a request is a summary of a more extended tabulation printed in the E. & M. Journal-Press, January 14th, 1922. The original table gives the location but not the name of each of the companies supplying information.

Both reciprocating and centrifugal pumps have advantages and disadvantages that give each type its particular field. Thus, for pumping a large volume of water under a low head, the centrifugal pump is excellently adapted, but for pumping under unusually high heads or greatly varying heads the reciprocating pump is more efficient. Between these extremes lies a zone covered by both types of pumps.

In general, the reciprocating pump is positive in action, rugged in construction, operates efficiently under many heads, and can often be run by more than one motive power. On the other hand, the centrifugal pump is simpler than the reciprocating type, has fewer moving parts, requires less attention, and is more compact, and hence requires less space than a plunger pump of the same capacity. However, it works best at a specified head, operation above and below which entails a sacrifice in efficiency. In general, the limit of single-stage centrifugal pumping is 75 to 200 ft. Multi-stage centrifugal pumps are in use to overcome the limitation of single-stage operation.

The centrifugal pump can be suddenly overloaded without damage to its mechanism, whereas an overload of a reciprocating pump through an obstruction or otherwise may seriously injure the machine. The ratio of efficiency between plunger and centrifugal pumps is about 4:3. The advantages of the centrifugal pump makes its use particularly desirable in a mine where pumping is generally done under a fixed head. However, an investigation conducted by Engineering and Mining Journal for the purpose of ascertaining to what extent each type of pump is used in the mines, smelters, and mills of Canada and Mexico, as well as in those of the United States, indicates that the reciprocating type is the more generally favored.

A detailed tabulation of pumping installations in North America from companies willing to supply this information follows. The data are not always complete and the survey is not comprehensive enough to give more than a general idea of pumping practice. We know of no publication giving this information.

It will be noted that the reciprocating pumps greatly outnumber the centrifugals, a circumstance that may be due partly to the older age of the reciprocating pump and its slow displacement by the centrifugal pump (if displacement is going on). Centrifugal pumps, however, seem to be fairly well intrenched in mill work. As a similar investigation too long to reproduce here discloses, of 430 pumps used in various mills of this continent 326 were centrifugal and 104 reciprocating.

METAL MINED	Number of Mines	Number of Pumps	DRIVE			TYPE OF PUMP																				Estimated Capacity in Gallons Per Minute	Head in Feet	SERVICE					
			†Steam	Electric	Air	Centrifugal	Simplex	Duplex	Triplex	Compound	Comp. Duplex	Trip. Exp.	Trip. Ex. Duplex	§Reciprocating	Tri. Duplex	Plunger	Tri. Plunger	Quin. Plunger	Quintuplex	Vert. Triplex	Cornish	†Sinkers	Deep Well	Lift	Sand			Drainage	Acid Mine Water	Station Pumps	Sinking	Unwatering	Hydraulic
Copper	47	131	24	66	41	8	27	23	8	2	4	4	4			8	4	3	27	6		3				60,000	12-1500	115			16		
Lead	5	18	4	11	3	7	4		4							3										6,000	45-1000	18					
Zinc	15	63	15	48	*3	31	5	7	4					6							4		5	1		33,000	100-1300	62			1		
Gold	6	25	20	5		11	5		7													2				12,500	200-1800	18			7		
Silver	3	15	4	10	1	10		3								1						1				9,000	100- 465	15					
Iron	36	98	19	77	2	43	5	7	21	1	3		4	2	2	10										48,800	30-1200	98					
Pyrites	1	2		2		2																				150	- 100	2					
Phosphate	10	46	16	30		29					3		11												3	61,000	17- 400						46
Copper—Lead	1	3		2	1											2						1				250	130- 800	2			1		
Lead—Silver	1	1			1	1																				50	- 200	1					
Lead—Fluorspar	5	19	18	1		1	4	3		6	1			3		1										11,000	200-1300	11		7	1		
Silver- Gold	19	50	2	39	9	15		6	20	2						7										13,400	75-1600	37			11	2	
Zinc—Pyrites	1	5	2	3					3							2										1,100	150- 225		5				
Iron—(Open Pit)	2	2	2					2																			60- 100	2					
TOTALS	152	478	126	294	61	158	50	51	67	11	11	4	19	11	2	34	4	3	27	6	4	7	5	1	3	256,250	12-1800	381	5	7	37	2	46

*Air or Steam.

†Other types are used as sinking pumps.

‡All stages of centrifugals classed together.

§"Reciprocating" where not otherwise classified.

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AIR LIFT PUMPING

Air-lift pumping had its first useful application on the Pacific coast. It was patented by James R. Frizell in 1880 and considerably improved by Dr. Julius I. Pohle, to whom patents were granted in 1886.

The arrangement is remarkably simple, consisting of the eduction pipe for the water and an air pipe which discharges compressed air in bubbles at the bottom of the pump. See Figure 38.

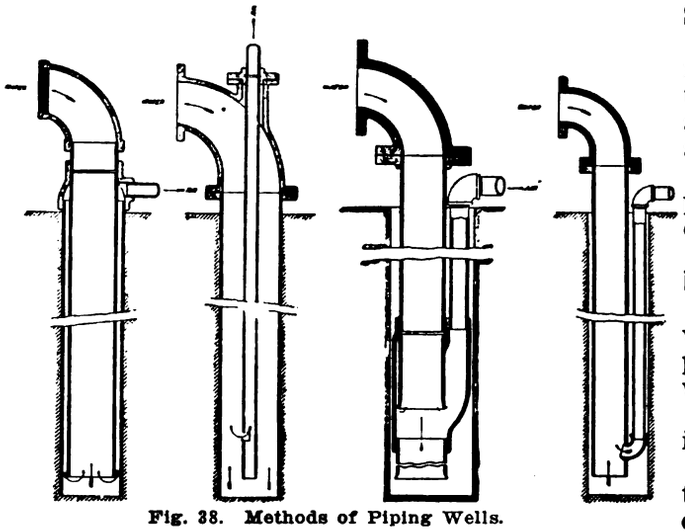

Fig. 38. Methods of Piping Wells.

The air lift contains no movable parts to get out of order, requires no lubrication, handles water that would be destructive to ordinary mine pumps and is not affected by mud or grit. Its principal claim to superiority lies in its large capacity. Under favorable conditions an air-lift pump will discharge more liquid than will any other type.

The principle involved in its action is the decreased specific gravity of the water in which air is contained in considerable quantity, or through which it is rising in bubbles. The lighter aerated water within the pipe is thus forced upwards by the static pressure of the water in the well and a flow created. Since the difference in the specific gravity between the two columns can never exceed a definite amount, it requires that the ratio of submergence to lift be within certain limits. The following table will be of interest.*

Ratio of Submergence to Lift.

	Submergence.
For lifts up to 50 feet.....	70 to 66 per cent.
50 to 100 feet.....	66 to 55 per cent.
100 to 200 feet.....	55 to 50 per cent.
200 to 300 feet.....	50 to 43 per cent.
300 to 400 feet.....	43 to 40 per cent.
400 to 500 feet.....	40 to 33 per cent.

In actual practice, it has been found that the submergence may be varied with the lift, shorter lifts requiring a greater percentage of submergence. While there is no definite division line, the proportion of submergence to lift, shown in the above table, will be found effective.

It will be readily understood that the diameter of the discharge or eduction pipe is of prime importance to secure the best efficiency, and must bear a relation not only to the amount of water to be handled, but also to the amount of air; so that for an equal amount of water the pipe size may vary with the lift and also with the percentage of submergence, as both factors change the amount of air. If the pipe is too large, then there is slippage of the air past the water, unless more air is used to keep up the velocity; or if too small a pipe is used, undue friction will increase the power needed.

*From Bulletin No. 71-A, Sullivan Machinery Company.

Standard Terms Used in Air Lift Work

Fig. 39 illustrates the terms regularly used in referring to air lift pumping, and these terms and their application should be thoroughly understood as a preliminary to study of the subject. They are explained more fully below.

1. Static Head—Normal water level when not pumping, measured from surface or top of well casing.

2. Drop—Point to which the water level drops below the static head while being pumped.

3. Pumping Head—Level of water when pumping as compared to ground surface or top of well casing.

Static Head + Drop = Pumping Head.

4. Elevation — Point above the ground surface or top of well casing to which water is raised.

5 Total Lift—Distance water is elevated, from level when pumping, to point of discharge, at an elevation, and includes:

Elevation + Static Head + Drop = Total Lift.

6. Lift—Distance the water is elevated from level when pumping to point of discharge at surface, and includes:

Static Head + Drop = Lift (or Pumping Head).

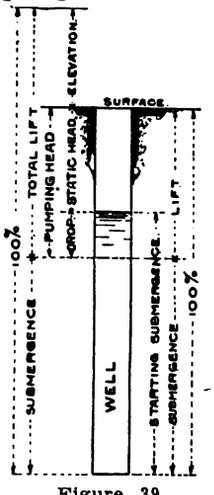

Figure 39. Illustrating Terms Used in Air-Lift Pumping.

7. Submergence—Distance below the pumping head at which the air picks up the water.

8. 100 Per Cent.—The vertical distance the air travels with the water from point introduced to point discharged, and includes:

Total Lift or Lift+Submergence=100 per cent.

9. Starting Submergence—Distance below the static head at which the air picks up the water, and includes:

Drop + Submergence = Starting Submergence.

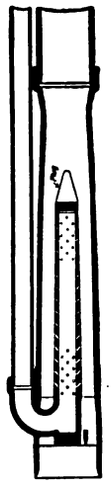

Fig. 40. Foot Piece.

In order to avoid the formation of large bubbles in the delivery pipe, a foot piece is used from which the compressed air issues in fine streams, thereby insuring a more intimate mixture with the water. See Fig. 40.

Air lifts have been used for many years to increase the flow from artesian wells for which they are particularly well adapted. The water supply for many cities is derived in this manner. The principle of the system is applicable to certain conditions in mining, such as raising water from the flooded lower sections of a mine to a point where it can be sent to the surface by the prevailing

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methods. It may be used to great advantage in coal washing for pumping the water from the settling tanks back to the jigs, and sundry other uses.

The efficiency of the air lift depends upon the mixture of air and water, the percentage of submergence and the proper proportioning of the eduction pipe, which bears a definite relation, not only to the volume of water passing through it but also to the air. If the pipe is too large, then there is slippage of the air past the water, unless more air is used to keep up the velocity; or if too small a pipe is used the frictional losses will be large.

While the efficiency of this pumping system may not reach over 40 per cent., its simplicity, the rapidity with which it may be installed in time of emergency and its low first cost may make its utility of more importance than its efficiency. An example of its adaptability to mining is supplied in the unwatering of Crown Hill No. 1 mine, at Clinton, Indiana.* Water had broken into the mine through the caving of an old room, in such quantities as to necessitate the stoppage of work. A drill hole, 160 feet deep, was put down from the surface to intersect an entry in the flooded section, and an air lift installed. The discharge pipe was 6 inches in diameter and inside this was the 1¼ inch air pipe. The mine was successfully recovered by keeping the lift in continuous operation 24 hours each day for a period of four months.

An illustration of the high head against which the air lift can operate is afforded by a mine in the Rocky Mountain section. The pump takes air from a high-pressure compressed-air locomotive service main, and lifts 160 gallons of water per minute more than 700 feet vertically. The air is delivered to the eduction pipe through a 5-32 inch round hole drilled in a solid plug cock.

Instructions for Securing Well Data

In order to make an intelligent and accurate estimate on an air lift installation, the information called for in the following list is absolutely necessary. The sketch and terms preceding should be understood fully before attempting to follow the paragraphs below.

Every item shown is of value in determining a proper installation, and it is of special importance to make a sketch showing the position and distance of the wells with regard to the location of the compressor and point of discharge.

1. Number of Wells. If more than one well is to be installed, a designating number used by the customer is of value, to avoid confusion in correspondence and proposals.

2. Depth in Feet. The depth is always of importance, and if not accurately known, soundings should be taken. Give the entire depth of the well.

3. Depth Cased. The depth to which the well is cased is important, because it may become necessary to use the casing as a discharge line.

4. Is the Casing Tight? It should be known if the casing is tight, for the same reason as above, and also for possible use in "back-blowing."

5 and 6. Diameter of Well in Inches and Character of Casing. This information is required to make up well top flanges. State the exact size, whether it is threaded or not, and the number of threads per inch. Sometimes a customer will assume he has a 6-inch well when measurement will show it to be 5⅝-inch or 6¼-inch.

*"Coal Age," Volume 5, pg. 121.

The usual term for the pipe forming the walls of a well is "casing"—sometimes it is standard pipe and sometimes casing which has different diameters and threads from standard pipe.

7 and 8. Reductions. It is important to know how much and at what point a well is reduced in order to determine the size of pump, water and air piping to be used.

9.—Character of Strata. After noting the initial in this line give the information in full elsewhere. The character of sand or gravel should be stated, whether fine or coarse, also the character of rock strata, sand, shale or limestone, and the name of the strata, if obtainable.

10. Depth to Water Strata. If there is more than one water-bearing stratum, give the depth to the principal one and note elsewhere the location of the others. From this information the probable drop and increase in flow may often be estimated.

11. Strainer. Sometimes the strainer is made part of the well casing, and sometimes it is dropped through the casing. Full knowledge is important to determine what effect "back-blowing" will have and whether the strainer is of a diameter to admit the required piping.

12. Static Head. From the static head is determined the starting pressure and consequent starting horse power. To a large extent it determines the size of the compressor installation.

13 and 14. Gallons Per Minute That Have Been Secured. These items, taken in connection with:

15 and 16. Are the Principal Factors in Determining the Proposal.

17, 18 and 19. Complete information is essential, especially where air power has been used previously.

20 and 21. Actual distances should be ascertained, and if the piping is in place, show the diameter; also note elbows and general description with sketch.

22, 23, 24 and 25. Complete information is important.

26. Sketch. A sketch should always be furnished, especially if there is more than one well and if it is desired to pump to an elevation. It is desirable to supply any information obtainable with regard to the action of similar wells in the vicinity, noting their size, depth, pumping heads and capacities.

WATER PRESSURE AT VARIOUS HEADS

Feet Head	Lbs. per Sq. In.	Feet Head	Lbs. per Sq. In.	Feet Head	Lbs. per Sq. In.	Feet Head	Lbs. per Sq. In.
1	0.43	160	69.31	260	112.62	500	216.58
5	2.17	165	71.47	265	114.79	550	238.24
10	4.33	170	73.64	270	116.96	600	259.90
				275	119.12		
25	10.83	175	75.80	280	121.29	650	281.56
50	21.66	180	77.97	285	123.45	700	303.22
60	25.99	185	80.14	290	125.62	750	324.88
80	34.65	190	82.30	295	127.78	800	346.54
100	43.31	195	84.47	300	129.95	850	368.20
105	45.48	200	86.63	310	134.28	900	389.86
110	47.64	205	88.80	320	138.62	950	411.52
115	49.81	210	90.96	330	142.95	1000	433.18
120	51.98	215	93.14	340	147.28		
125	54.15	220	95.30	350	151.61		
130	56.31	225	97.49	360	155.94		
135	58.48	230	99.63	370	160.27		
140	60.64	235	101.79	380	164.61		
145	62.81	240	103.96	390	168.94		
150	64.97	245	106.13	400	173.27		
		250	108.29				
155	67.14	255	110.46	450	194.92		

Courtesy Fraser & Chalmers Co.

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LOSS OF HEAD OF WATER IN PIPES BY FRICTION—FOR AIR LIFT COMPUTATIONS

Friction Head, in Feet, for each 100 feet of Pipe, for clean Iron Pipe of the Sizes shown, Discharging given Volumes in Gallons per Minute.

Gals. per Min.	Loss of Head Due to Friction, in Feet and Pipe in Inches													Gals. per Min.
	¾	1	1¼	1½	2	2½	3	3½	4	5	6	7	8	
5	7.59	1.93	0.71	0.27	0.092	0.046	.....	.....	.....	.....	.....	.....	.....	5
10	29.90	10.26	2.41	1.08	0.277	0.092	0.046	.....	.....	.....	.....	.....	.....	10
15	66.01	16.05	5.47	2.23	0.577	0.185	0.092	0.046	.....	.....	.....	.....	.....	15
20	115.92	28.29	9.36	3.81	0.97	0.323	0.138	0.069	.....	.....	.....	.....	.....	20
25	180.00	43.70	14.72	5.02	1.43	0.485	0.231	0.092	.....	.....	.....	.....	.....	25
30	.....	63.25	21.04	8.62	2.09	0.693	0.30	0.138	.....	.....	.....	.....	.....	30
35	.....	85.10	28.52	11.61	2.76	0.92	0.393	0.208	.....	.....	.....	.....	.....	35
40	.....	110.40	37.03	14.99	3.68	1.19	0.53	0.254	0.1383	.....	.....	.....	.....	40
45	.....	.....	46.46	18.74	4.60	1.49	0.647	0.323	0.1615	.....	.....	.....	.....	45
50	.....	.....	57.27	23.00	5.61	1.86	0.80	0.393	0.208	.....	.....	.....	.....	50
60	.....	.....	85.50	32.95	8.88	2.70	1.155	0.555	0.30	0.1156	.....	.....	.....	60
70	.....	.....	114.00	44.60	11.09	3.46	1.385	0.879	0.439	0.162	.....	.....	.....	70
75	.....	.....	129.00	51.42	12.23	4.14	1.70	0.913	0.485	0.174	.....	.....	.....	75
80	.....	.....	.....	58.45	14.55	4.62	2.08	0.948	0.581	0.185	.....	.....	.....	80
90	.....	.....	.....	81.50	18.02	5.96	2.54	1.247	0.60	0.208	.....	.....	.....	90
100	.....	.....	.....	89.70	21.75	7.36	3.01	1.478	0.763	0.277	0.115	.....	.....	100
125	.....	.....	.....	.....	34.27	11.24	4.57	2.219	1.13	0.393	0.161	.....	.....	125
150	.....	.....	.....	.....	48.76	16.10	6.55	3.12	1.59	0.578	0.231	0.0924	.....	150
175	.....	.....	.....	.....	.....	21.75	8.85	4.208	2.146	0.785	0.302	0.115	.....	175
185	.....	.....	.....	.....	.....	24.50	9.94	4.62	2.484	0.84	0.36	0.13	.....	185
200	.....	.....	.....	.....	.....	28.68	11.54	5.50	2.82	0.972	0.393	0.162	.....	200
250	.....	.....	.....	.....	.....	.....	17.84	8.55	4.37	1.504	0.601	0.2775	0.162	250
265	9 in.	10 in.	12 in.	14 in.	15 in.	18 in.	20.09	9.60	4.645	1.69	0.70	0.31	0.175	265
300	0.115	.....	.....	.....	.....	.....	25.76	11.63	6.15	2.15	0.85	0.393	0.208	300
350	0.1618	.....	.....	.....	.....	.....	.....	16.40	8.44	2.914	1.15	0.531	0.2775	350
370	0.178	.....	.....	.....	.....	.....	.....	18.18	9.33	3.197	1.33	0.59	0.306	370
400	0.208	.....	.....	.....	.....	.....	.....	21.36	10.92	3.72	1.50	0.693	0.37	400
450	0.2545	0.1618	.....	.....	.....	.....	.....	.....	13.88	4.62	1.87	0.855	0.462	450
480	0.3	0.1816	.....	.....	.....	.....	.....	.....	14.34	5.06	2.16	0.96	0.498	480
500	0.324	0.204	0.0925	.....	.....	.....	.....	.....	17.16	5.55	2.22	1.04	0.5785	500
750	0.6945	0.416	0.1848	.....	.....	.....	.....	.....	.....	11.28	5.11	2.34	1.224	750
1000	1.224	0.74	0.304	0.1432	.....	.....	.....	.....	.....	.....	8.98	4.16	2.17	1000
1100	1.50	0.88	0.375	0.18	.....	.....	.....	.....	.....	.....	10.90	5.08	2.64	1100
1250	1.895	1.132	0.462	0.22	.....	.....	.....	.....	.....	.....	13.86	6.60	3.378	1250
1500	2.704	1.618	0.67	0.306	0.22	.....	.....	.....	.....	.....	.....	9.45	4.84	1500
2000	.....	2.842	1.132	0.541	0.38	0.195	.....	.....	.....	.....	.....	.....	8.70	2000
2200	.....	3.34	1.38	0.68	0.455	0.26	.....	.....	.....	.....	.....	.....	10.71	2200
2500	.....	4.43	1.78	0.8365	0.575	0.295	.....	.....	.....	.....	.....	.....	.....	2500
3000	.....	6.30	2.567	1.19	0.79	0.405	.....	.....	.....	.....	.....	.....	.....	3000

LOSS OF HEAD OF WATER IN ELBOWS, DUE TO FRICTION (IN FEET)

(Calculated from Weisback's formula for very short bends, with a radius equal to the radius of the pipe)

Gals. per Min.	Loss of Head Due to Friction in Feet, and Size of Elbows in Inches													Gals. per Min.
		1	1	1	2	2	3	3	4	5	6	7	8	
5	0.161	0.0624	0.0185	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
10	0.644	0.217	0.716	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
15	1.449	0.488	0.1592	0.092	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
20	2.576	0.8675	0.2835	0.1591	.....	.....	.....	.....	.....	.....	.....	.....	.....	20
25	4.002	1.35	0.448	0.249	0.0878	.....	.....	.....	.....	.....	.....	.....	.....	20
30	.....	1.95	0.642	0.362	0.127	.....	.....	.....	.....	.....	.....	.....	.....	5
35	.....	2.65	0.877	0.495	0.1755	0.0854	.....	.....	.....	.....	.....	.....	.....	35
40	.....	3.46	1.143	0.641	0.2264	0.1131	.....	.....	0.01614	.....	.....	.....	.....	40
45	.....	.....	1.445	0.81	0.288	0.143	0.0599	.....	0.0208	.....	.....	.....	.....	54
50	.....	.....	1.778	0.99	0.353	0.1848	0.0738	.....	0.0231	.....	.....	.....	.....	50
60	.....	.....	2.562	1.429	0.5075	0.258	0.1015	0.06	0.345	0.01382	.....	.....	.....	60
70	.....	.....	3.51	1.982	0.701	0.3415	0.1383	0.0808	0.0485	0.0208	.....	.....	.....	70
75	.....	.....	4.02	2.26	0.808	0.397	0.166	0.0923	0.0552	0.0231	.....	.....	.....	75
80	.....	.....	4.57	2.56	0.925	0.452	0.1845	0.1014	0.0623	0.0277	.....	.....	.....	80
90	.....	.....	.....	3.25	1.156	0.573	0.2395	0.1385	0.0808	0.0323	.....	.....	.....	90
100	.....	.....	.....	.....	1.412	0.738	0.295	0.1569	0.0992	0.0392	0.01845	.....	.....	100
125	.....	.....	.....	.....	2.24	1.175	0.462	0.258	0.1546	0.0622	0.03	.....	.....	125
150	.....	.....	.....	.....	3.205	1.58	0.659	0.3695	0.2215	0.09	0.0438	0.0231	.....	150
175	.....	.....	.....	.....	.....	2.16	0.899	0.504	0.3048	0.1222	0.06	0.0326	.....	175
185	.....	.....	.....	.....	.....	2.42	1.055	0.5745	0.348	0.1342	0.068	0.0349	.....	185
200	.....	.....	.....	.....	.....	2.955	1.18	0.628	0.397	0.157	0.0738	0.0462	.....	200
250							1.845	1.029	0.195	0.252	0.11967	0.0669	0.0392	250
265	9 in.	10 in.	12 in.	14 in.	15 in.	18 in.	2.35	1.183	0.7025	0.2743	0.1404	0.076	0.0441	265
300	0.0369	.....	.....	.....	.....	.....	2.63	1.478	0.886	0.36	0.1754	0.0969	0.0577	300
350	0.0507	.....	.....	.....	.....	.....	.....	2.03	1.244	1.244	0.496	0.2375	0.1314	350
370	0.0573	.....	.....	.....	.....	.....	.....	2.302	1.356	0.535	0.273	0.149	0.0843	370
400	0.0646	.....	.....	.....	.....	.....	.....	2.515	1.586	0.6275	0.395	0.1845	0.1015	400
450	0.083	0.053	.....	.....	.....	.....	.....	.....	2.015	0.811	0.392	0.217	0.1315	450
480	0.088	0.0563	.....	.....	.....	.....	.....	.....	2.256	0.901	0.4602	0.2454	0.144	480
500	0.1015	0.065	0.0369	.....	.....	.....	.....	.....	2.47	1.007	0.481	0.2675	0.1568	500
750	0.231	0.1453	0.0715	.....	.....	.....	.....	.....	.....	2.24	1.0825	0.60	0.3598	750
1000	0.306	0.258	0.1439	0.0772	.....	.....	.....	.....	.....	4.02	1.92	1.069	0.627	1000
1100	0.4615	0.293	0.145	0.0917	.....	.....	.....	.....	.....	.....	2.413	1.329	0.756	1100
1250	0.637	0.403	0.1981	0.1185	.....	.....	.....	.....	.....	.....	3.025	1.676	1.005	1250
1500	0.923	0.286	0.1695	0.112	.....	.....	.....	.....	.....	.....	.....	1.938	1.44	1500
2000	1.535	1.008	0.4747	0.393	0.1985	0.115	.....	.....	.....	.....	.....	.....	2.44	2000
2200	1.85	1.183	0.5805	0.367	0.249	0.1548	.....	.....	.....	.....	.....	.....	3.025	2200
2500	2.395	1.568	0.751	0.475	0.311	0.1795	.....	.....	.....	.....	.....	.....	3.88	2500
3000	3.46	2.248	1.082	0.690	0.4485	0.258	.....	.....	.....	.....	.....	.....	.....	3000

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Useful Information on Pumps and Pipe Lines

WHEN ORDERING PUMPS

Manufacturer wants to know:—

How many gallons you want to handle per minute.

The amount of suction lift, length and size of suction pipes. If you want to use one or more branches to suction, so state.

The amount of discharge lift, length and size of discharge pipe. If other pumps use same discharge line, so state, giving approximate quantity of water passing through line.

Will the water contain any solids? Give character of water and state preference as to metal to be used in water end of pump.

If steam is to be used, give boiler pressure, length, size and condition of steam line and probable pressure at the pump.

If compressed air is to be used, give air pressure at the pump.

If electricity is to be used, give voltage and state whether alternating or direct current. If alternating, state if single phase, two or three phase, the voltage and number of cycles. Does voltage vary materially?

Courtesy Harris Pump & Supply Co

TABLE OF CAPACITY OF PUMPS

The figures at the extreme right and left of the Table are plunger or piston diameters; the line of figures across the top are length of plunger or piston strokes; the figures in the body of the Table are the capacity, or displacement in U. S. gallons, corresponding to a single stroke. To find the capacity for one revolution, multiply the capacity for a single stroke by one, two, three, four or five, for single, duplex, triplex quadruplex or quintuplex, single-acting; and by two, four, six, eight or ten, for double-acting pumps.

Diam. Plunger Inches	LENGTH OF STROKE IN INCHES, AND CAPACITY PER STROKE IN U. S. GALLONS, OF PUMP CYLINDER, WITH GIVEN DIAMETER																	Diam. Plunger Inches
	1	4	5	6	7	8	9	10	12	14	16	18	20	24	30	36	48	
1¼	.0053	.0212	.0266	.0319	.0372	.0425	.0478	.0531	.0637	.0743	.0848	.0955	.1062	.1274	.1590	.1908	.2544	1¼
1⅜	.0064	.0256	.0321	.0385	.0419	.0513	.0578	.0642	.077	.089	.1027	.1156	.1280	.1541	.1920	.2304	.3072	1⅜
1½	.00765	.0306	.0382	.0459	.0535	.0612	.0688	.0765	.0918	.1071	.1224	.1377	.1530	.1836	.2295	.2754	.3672	1½
1¾	.0104	.0416	.0521	.0625	.0729	.0833	.0937	.1041	.1249	.1457	.1666	.1874	.2082	.2499	.3120	.3744	.4992	1¾
2	.0136	.0544	.068	.0816	.0952	.1088	.1224	.136	.1632	.1904	.2176	.2448	.2720	.3264	.4080	.4896	.6528	2
2¼	.0172	.0688	.086	.1033	.1205	.1377	.1548	.1721	.2063	.241	.2754	.3096	.344	.4128	.5160	.6192	.8256	2¼
2½	.02125	.0850	.1062	.1275	.1487	.17	.1912	.2125	.255	.2975	.34	.3825	.4252	.51	.6375	.7650	1.0200	2½
2¾	.0257	.1028	.1285	.1543	.1799	.2057	.2313	.2571	.3085	.3598	.4114	.4626	.5142	.617	.7710	.9252	1.2336	2¾
3	.0306	.1224	.1530	.1836	.2142	.2448	.2754	.306	.3672	.4284	.4896	.5508	.612	.7344	.9180	1.1016	1.4688	3
3¼	.0359	.1486	.1795	.2154	.2513	.2872	.3231	.3594	.4312	.503	.5748	.6466	.7182	.8624	1.0770	1.2924	1.7232	3¼
3½	.04165	.1666	.2082	.2499	.2915	.3322	.3748	.4165	.4998	.5831	.6664	.7497	.833	.9996	1.7495	1.4994	1.9992	3½
3¾	.0478	.1912	.239	.2868	.3346	.3824	.4302	.478	.5736	.6692	.7648	.8605	.9561	1.147	1.4340	1.7208	2.2944	3¾
4	.0544	.2176	.272	.3264	.3808	.4352	.4896	.544	.6528	.7616	.8704	.9792	1.088	1.3050	1.6320	1.9584	2.6112	4
4¼	.0614	.....	.307	.3684	.4298	.4912	.5526	.6141	.7368	.8596	.9824	1.105	1.228	1.473	1.8420	2.2104	2.9472	4¼
4½	.06885	.....	.3442	.4131	.4819	.5508	.6196	.6885	.8262	.9639	1.1016	1.2393	1.377	1.6524	2.0655	2.4786	3.3048	4½
4¾	.0767	.....	.3835	.4602	.5369	.6136	.6903	.7671	.9204	1.073	1.227	1.380	1.534	1.84	2.3010	2.7612	3.6816	4¾
5	.0850	.....	.425	.51	.595	.68	.765	.85	1.02	1.19	1.36	1.53	1.7	2.04	2.5500	3.0600	4.0800	5
5¼	.0937	.....	.....	.5622	.6559	.7496	.8433	.9371	1.124	1.311	1.499	1.686	1.874	2.248	2.8110	3.3732	4.4976	5¼
5½	.10285	.....	.....	.6171	.7199	.8228	.9256	1.0285	1.2342	1.4399	1.6456	1.8513	2.057	2.4684	3.0855	3.7026	4.9368	5½
5¾	.1124	.....	.....	.6744	.7868	.8992	1.011	1.124	1.348	1.573	1.789	2.022	2.248	2.696	3.3720	4.0464	5.3952	5¾
6	.1224	.....	.....	.7314	.8568	.9792	1.1016	1.2240	1.4688	1.7136	1.9584	2.2032	2.448	2.9376	3.6720	4.4064	5.8752	6
6¼	.1328	.....	.....	.7968	.9296	1.062	1.195	1.328	1.593	1.859	2.124	2.39	2.656	3.186	3.9840	4.7808	6.3744	6¼
6½	.1436	.....	.....	.8610	1.0052	1.1488	1.2926	1.4364	1.724	2.0109	2.2982	2.5885	2.8728	3.4473	4.3080	5.1696	6.8928	6½
6¾	.1549	.....	.....	.9294	1.084	1.239	1.394	1.549	1.858	2.168	2.479	2.788	3.098	3.716	4.6470	5.5764	7.4352	6¾
7	.1666	.....	.....	.9996	1.1662	1.3328	1.4994	1.666	1.9992	2.3324	2.6656	2.9988	3.332	3.9984	4.9980	5.9976	7.9968	7
7¾	.2042	.....	.....	1.225	1.429	1.633	1.837	2.042	2.45	2.858	3.266	3.674	4.084	4.9	6.1260	7.3512	9.8016	7¾
8	.2176	.....	.....	1.3056	1.5232	1.7408	1.9584	2.176	2.6112	3.0464	3.4816	3.9168	4.352	5.2224	6.5280	7.8336	10.4448	8
9	.2754	.....	.....	.....	1.9278	2.2032	2.4786	2.754	3.3048	3.8556	4.4064	5.0572	5.508	6.6096	8.2620	9.9144	13.2192	9
10	.3400	.....	.....	.....	.....	2.72	3.06	3.4	4.08	4.76	5.44	6.12	6.8	8.16	10.20	12.2400	16.3200	10
11	.41135	.....	.....	.....	.....	.....	3.7258	4.1139	4.9367	5.7595	6.5823	7.4051	8.2279	9.8735	12.34	14.8086	19.7448	11
12	.4896	.....	.....	.....	.....	.....	.....	4.896	5.8752	6.8544	7.833	8.8128	9.792	11.7504	14.688	17.6256	23.5008	12
13	.5745	.....	.....	.....	.....	.....	.....	.....	6.894	8.042	9.192	10.34	11.49	13.78	17.235	20.6820	27.5760	13
14	.6660	.....	.....	.....	.....	.....	.....	.....	7.994	9.328	10.66	11.99	13.32	15.98	19.98	23.9760	31.968	14
15	.7645	.....	.....	.....	.....	.....	.....	.....	.....	10.70	12.23	13.76	15.29	18.35	22.935	27.5220	36.696	15
16	.8700	.....	.....	.....	.....	.....	.....	.....	.....	12.18	13.92	15.66	17.40	20.88	26.10	31.3200	41.760	16
18	1.1010	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.61	19,81	22.02	26.42	33.03	39.636	52.848	18
20	1.3600	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.76	24.48	27.2	32.64	40.80	48.96	65.280	20

Courtesy of The Aldrich Pump Co.

EQUIVALENTS OF LIQUID MEASURES AND WEIGHTS

Measures and Weigths for Comparison	Measure and Weight Equivalents of Items in First Column								
	U. S. Gallon	Imperial Gallon	Cubic Inch	Cubic Foot	Cubic Meter	Liter	Pound	*Vedro	*Pood
U.S. Gal.	1.	.833	231.	.1337	.00378	3.785	8.33	.308	.231
Imp. Gal	1.20	1.	277.27	.1604	1.00454	4.542	10.	.369	.277
Cu. In..	.0043	.00358	1.	.00057	.000016	.0163	.0358	.00132	.001
Cu. Ft...	7.48	6.235	1728.	1.	.02827	28.312	62.355	2.304	1.728
Cu. Met.	264.17	220.05	61023.	35.319	.	1000.	2200.54	81.364	61.023
Liter ...	.26417	.2200	61.023	.0353	.001	1.	2.2005	.08136	.06102
*Vedro	3.249	2.706	750.1	.4344	.01228	12.29	27.06	1.	.7501
*Pood.	4.328	3.607	1000.	.578	.01636	16.381	36.07	1.333	1.
Pound ..	.12	.1	27.72	.016	.00045	.454	1.	.0369	.0277

*Vedro and Pood are a Russian measure and weight respectively

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Useful Information on Pumps and Pipe Lines---Cont.

THE COST OF PUMPING

The cost (in dollars) per month (30 days of 24 hours each) of pumping 100 U. S. gallons per minute against 1 ft. lift—the efficiency of Pump and Motor together and the cost of Power being known.

RATE	COST		COMBINED EFFICIENCY—MOTOR AND PUMP—PER CENT.											
(Cents) K.W. Hr.	(Cents) H. P. Hour	(Dollars) H. P. Year	40	45	50	55	60	65	70	73	76	80	83	86	90
			Cost per month (30 days—24 hours each) 100 U. S. Gallons per minute against 1 ft. Lift											
0.1	.0007	6.54	.034	.030	.027	.029	.023	.021	.019	.019	.018	.017	.016	.016	.015
0.2	.0015	13.07	.068	.060	.054	.049	.045	.042	.039	.037	.036	.034	.033	.032	.030
0.3	.0022	19.61	.102	.091	.082	.074	.068	.063	.058	.056	.054	.051	.049	.047	.045
0.4	.0030	26.14	.136	.121	.109	.099	.091	.084	.078	.074	.072	.068	.065	.063	.060
0.5	.0037	32.68	.170	.151	.136	.123	.113	.104	.097	.093	.089	.085	.082	.079	.075
0.6	.0045	39.21	.204	.181	.163	.148	.136	.125	.116	.112	.107	.102	.098	.095	.091
0.7	.0052	45.75	.238	.211	.190	.173	.158	.146	.136	.130	.125	.119	.115	.111	.106
0.8	.0060	52.28	.272	.241	.217	.198	.181	.167	.155	.149	.143	.136	.131	.126	.121
0.9	.0067	58.82	.305	.272	.244	.222	.204	.188	.175	.167	.161	.153	.147	.142	.136
1.0	.0075	65.35	.339	.302	.272	.247	.226	.209	.194	.186	.179	.170	.164	.158	.151
1.1	.0082	71.89	.373	.332	.299	.272	.249	.230	.213	.205	.197	.187	.180	.174	.167
1.2	.0090	78.42	.407	.362	.326	.296	.272	.251	.233	.223	.214	.204	.196	.189	.181
1.3	.0097	84.96	.441	.392	.353	.321	.294	.272	.252	.242	.232	.221	.213	.205	.196
1.4	.0104	91.49	.475	.422	.380	.346	.317	.292	.272	.260	.250	.238	.229	.221	.211
1.5	.0112	98.02	.509	.453	.407	.370	.339	.313	.291	.279	.268	.255	.245	.237	.226
1.6	.0119	104.56	.543	.483	.434	.395	.362	.334	.310	.298	.286	.271	.262	.253	.241
1.7	.0127	111.09	.577	.513	.462	.420	.385	.355	.330	.316	.304	.288	.278	.268	.256
1.8	.0134	117.63	.611	.543	.489	.444	.407	.376	.349	.335	.322	.305	.294	.284	.272
1.9	.0142	124.16	.645	.573	.516	.469	.430	.397	.368	.353	.339	.322	.311	.300	.287
2.0	.0149	130.70	.679	.603	.543	.494	.453	.418	.388	.372	.357	.339	.327	.316	.302
2.1	.0157	137.23	.713	.633	.570	.518	.475	.439	.407	.391	.375	.356	.343	.332	.317
2.2	.0164	143.77	.747	.664	.597	.543	.498	.459	.427	.409	.393	.373	.360	.347	.332
2.3	.0172	150.30	.781	.694	.624	.568	.520	.480	.446	.428	.411	.390	.376	.363	.347
2.4	.0179	156.84	.814	.724	.652	.592	.543	.501	.465	.446	.429	.407	.393	.379	.362
2.5	.0187	163.37	.848	.754	.679	.617	.566	.522	.485	.465	.447	.424	.409	.395	.377
2.6	.0194	169.91	.882	.784	.706	.642	.588	.543	.504	.484	.464	.441	.425	.410	.392
2.7	.0201	176.44	.916	.814	.733	.666	.611	.564	.524	.502	.482	.458	.442	.426	.407
2.8	.0209	182.98	.950	.845	.760	.691	.633	.585	.543	.521	.500	.475	.458	.442	.422
2.9	.0216	189.51	.984	.875	.787	.716	.656	.606	.562	.539	.518	.492	.474	.458	.437
3.0	.0224	196.05	1.018	.905	.814	.740	.679	.627	.582	.558	.536	.509	.491	.474	.453
3.1	.0231	202.58	1.052	.935	.842	.765	.701	.647	.601	.576	.554	.525	.507	.489	.468
3.2	.0239	209.12	1.086	.965	.869	.790	.724	.668	.621	.595	.572	.543	.523	.505	.483
3.3	.0246	215.65	1.120	.995	.896	.814	.747	.689	.640	.614	.589	.560	.540	.520	.498
3.4	.0254	222.19	1.154	1.025	.923	.839	.769	.710	.659	.632	.607	.577	.556	.536	.513
3.5	.0261	228.72	1.188	1.056	.950	.864	.792	.731	.679	.651	.625	.594	.572	.552	.528
3.6	.0269	235.26	1.222	1.086	.977	.888	.814	.752	.698	.669	.643	.611	.589	.568	.543
3.7	.0276	241.79	1.256	1.116	1.004	.913	.837	.773	.717	.688	.661	.628	.605	.583	.558
3.8	.0283	248.33	1.289	1.146	1.032	.938	.860	.794	.737	.707	.679	.645	.621	.599	.573
3.9	.0291	254.86	1.323	1.176	1.059	.963	.882	.814	.756	.725	.697	.662	.638	.615	.588
4.0	.0298	261.40	1.357	1.206	1.086	.987	.905	.835	.776	.744	.714	.679	.654	.631	.603
4.1	.0306	267.93	1.391	1.237	1.113	1.012	.928	.856	.795	.762	.732	.696	.671	.647	.618
4.2	.0313	274.47	1.425	1.267	1.140	1.037	.950	.877	.814	.781	.750	.713	.687	.663	.633
4.3	.0321	281.00	1.459	1.297	1.167	1.061	.973	.898	.834	.800	.768	.730	.703	.679	.649
4.4	.0328	287.54	1.493	1.327	1.194	1.086	.995	.919	.853	.818	.786	.747	.720	.694	.664
4.5	.0336	294.07	1.527	1.357	1.222	1.111	1.018	.940	.873	.837	.804	.764	.736	.710	.679
4.6	.0343	300.61	1.561	1.388	1.249	1.135	1.041	.961	.892	.855	.822	.780	.752	.726	.694
4.7	.0351	307.14	1.595	1.418	1.276	1.160	1.063	.981	.911	.874	.839	.797	.769	.742	.709
4.8	.0358	313.68	1.629	1.448	1.303	1.185	1.086	1.002	.931	.893	.857	.814	.785	.758	.724
4.9	.0366	320.21	1.663	1.478	1.330	1.209	1.108	1.023	.950	.911	.875	.831	.801	.773	.739
5.0	.0373	326.75	1.697	1.508	1.357	1.234	1.131	1.044	.970	.930	.893	.848	.818	.789	.755

To find the cost per month of Pumping any Quantity per minute against any Lift—Divide the desired number of U. S. Gallons per minute by 100 and multiply the Quotient by the required Lift and then by the value in the table found Opposite the price paid for Power, and Under the combined efficiency of Motor and Pump.

RELATIVE QUANTITIES OF WATER

Delivered in 24 Hours, in 1 Hour, and in 1 Minute

Gallons in 24 hours	Gallons in 1 hour	Gallons in 1 min.	Gallons in 24 hours	Gallons in 1 hour	Gallons in 1 min.	Gallons in 24 hours	Gallons in 1 hour	Gallons in 1 min.
2500000	104166.0	1736.0	650000	27083.3	451.3	150000	6250.0	104.1
2000000	83333.3	1388.0	600000	25000.0	416.7	100000	4166.6	69.4
1500000	62500.0	1041.7	550000	22916.6	381.9	75000	3125.0	52.9
1000000	41666.6	694.3	500000	20833.3	347.2	60000	2500.0	41.6
950000	39583.3	659.7	450000	18750 0	312 5	50000	2083.3	34.7
900000	37500.0	625.0	400000	16666.6	277.7	25000	1041.6	17.3
850000	35416.6	590.2	350000	14583.3	243.0	20000	833.3	13.8
800000	33333.3	555.5	300000	12500.0	208.3	15000	625.0	10.4
750000	31250.0	520.8	250000	10416.7	173.6	10000	416.6	6.9
700000	29166.6	486.1	200000	8333.3	138.8	5000	208.3	3.4

Courtesy of The Deming Company.

STROKES FOR PISTON SPEED OF 100 FEET PER MINUTE

Length of Stroke Inches	Number of Strokes	Length of Stroke Inches	Number of Strokes	Length of Stroke Inches	Number of Strokes
4	300	12	100	24	50
5	240	14	86	26	46
6	200	16	75	28	43
7	172	18	67	30	40
8	150	20	60	36	33
10	120	22	55	40	30

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Useful Information on Pumps and Pipe Lines---Cont.

THEORETICAL HORSE POWER REQUIRED TO RAISE WATER TO DIFFERENT HEIGHTS

Feet Elevation	5	10	15	20	25	30	35	40	45	50	60
Gallons per Min.											
5	.006	.012	.019	.025	.031	.037	.044	.05	.06	.06	.07
10	.012	.025	.037	.050	.062	.075	.087	.10	.11	.12	.15
15	.019	.037	.056	.075	.094	.112	.131	.15	.17	.19	.22
20	.025	.050	.075	.100	.125	.150	.175	.20	.22	.25	.30
25	.031	.062	.093	.125	.156	.187	.219	.25	.28	.31	.37
30	.037	.075	.112	.150	.187	.225	.262	.30	.34	.37	.45
35	.043	.087	.131	.175	.219	.262	.306	.35	.39	.44	.52
40	.050	.100	.150	.200	.250	.300	.350	.40	.45	.50	.60
45	.056	.112	.168	.225	.281	.337	.394	.45	.51	.56	.67
50	.062	.125	.187	.250	.312	.375	.437	.50	.56	.62	.75
60	.075	.150	.225	.300	.375	.450	.525	.60	.67	.75	.90
75	.093	.187	.281	.375	.469	.562	.656	.75	.84	.94	1.12
90	.112	.225	.337	.450	.562	.675	.787	.90	1.01	1.12	1.35
100	.125	.250	.375	.500	.625	.750	.875	1.00	1.12	1.25	1.50
125	.156	.312	.469	.625	.781	.937	1.094	1.25	1.41	1.56	1.87
150	.187	.375	.562	.750	.937	1.125	1.312	1.50	1.69	1.87	2.25
175	.219	.437	.656	.875	1.093	1.312	1.531	1.75	1.97	2.19	2.62
200	.250	.500	.750	1.000	1.250	1.500	1.750	2.00	2.25	2.50	3.00
250	.312	.625	.937	1.250	1.562	1.875	2.187	2.50	2.81	3.12	3.75
300	.375	.750	1.125	1.500	1.875	2.250	2.625	3.00	3.37	3.75	4.50
350	.437	.875	1.312	1.750	2.187	2.625	3.062	3.50	3.94	4.37	5.25
400	.500	1.000	1.500	2.000	2.500	3.000	3.500	4.00	4.50	5.00	6.00
500	.625	1.250	1.875	2.500	3.125	3.750	4.375	5.00	5.62	6.25	7.50

Feet Elevation	75	90	100	125	150	175	200	250	300	350	400
Gallons per Min.											
5	.09	.11	.12	.16	.19	.22	.25	.31	.37	.44	.50
10	.19	.22	.25	.31	.37	.44	.50	.62	.75	.87	1.00
15	.28	.34	.37	.47	.56	.66	.75	.94	1.12	1.31	1.50
20	.37	.45	.50	.62	.75	.87	1.00	1.25	1.50	1.75	2.00
25	.47	.56	.62	.78	.94	1.09	1.25	1.56	1.87	2.19	2.50
30	.56	.67	.75	.94	1.12	1.31	1 50	1.87	2.25	2.62	3.00
35	.66	.79	.87	1.08	1.31	1.53	1.75	2.19	2.62	3.06	3.50
40	.75	.90	1.00	1.25	1.50	1.75	2.00	2.50	3.00	3.50	4.00
45	.84	1.01	1.12	1.41	1.69	1.97	2.25	2.81	3.37	3.94	4.50
50	.94	1.12	1.25	1.56	1.87	2.19	2.50	3.12	3.75	4.37	5.00
60	1.12	1.35	1.50	1.87	2.25	2.62	3.00	3.75	4.50	5.25	6.00
75	1.40	1.69	1.87	2.34	2.81	3.28	3.75	4.69	5.62	6.56	7.50
90	1.68	2.02	2.25	2.81	3.37	3.94	4.50	5.62	6.75	7.87	9.00
100	1.87	2.25	2.50	3.12	3.75	4.37	5.00	6 25	7.50	8.75	10.00
125	2.34	2.81	3.12	3.91	4.69	5.47	6.25	7.81	9.37	10.94	12.50
150	2.81	3.37	3.75	4.69	5.62	6.56	7.50	9.37	11.25	13.12	15.00
175	3.28	3.94	4.37	5.47	6.56	7 66	8.75	10.94	13.12	15.31	17.50
200	3.75	4.50	5.00	6.25	7.50	8.75	10.00	12 50	15.00	17.50	20.00
250	4.69	5.62	6.25	7.81	9.37	10.94	12 50	15.72	18.75	21.87	25.00
300	5.62	6.75	7.50	9.37	11.25	13.12	15.00	18.75	22.50	26.25	30.00
350	6.56	7.87	8.75	10.94	13.12	15.31	17 50	21.87	26.25	30.62	35.00
400	7.50	9.00	10.00	12 50	15.00	17.50	20 00	25.00	30.00	35.00	40.00
500	9.37	11.25	12.50	15 62	18.75	21.87	25.00	31.25	37 50	43 75	50 00

The theoretical horse power required to elevate water is found by multiplying the gallons pumped per minute by the total lift (including friction) in feet, and dividing by 4000. To get the actual horse power required, divide the theoretical power obtained from the table above by the efficiency of the pump expressed as a decimal.

TO SELECT PROPER SIZE MOTOR FOR YOUR PUMP

Remember that feet elevation given in table includes three distinct elevations. First, actual difference in elevation of water to be pumped at its lowest point and highest point to which water is elevated; second, the equivalent of vertical feet necessary to overcome the friction caused by water handled in passing through all the line, including suction and discharge lines, the pump itself and all obstructions, including elbows, bends and gate valves. See Table for friction of water in pipes. Fig. 5 elbows the same as 100 feet of straight pipe. Use gate valves instead of globe valve for water wherever possible. Use swing checks instead of poppet checks; third, velocity heads. Ths is usually so small in mine service as to be neglected in calculations.

To find horse power required for a piston power pump, multiply theoretical horse power shown in table by ½ to 2. For triplex pumps up to 100 feet multiply by 1½ to 2. For elevations 100 to 200 feet, 1½; for elevations 200 to 400 feet, multiply by 1.4.

For deep water pumps, multiply by 2 to 3.

For centrifugal pumps, multiply by 2 to 2½.

In centrifugal pumps remember that the speed of motor and pump should be right for the elevation and when speeded too high or put on a lower elevation, more water will be pumped and much more power required.

BAROMETRIC PRESSURES

At Different Altitudes, with Equivalent Head of Water and the Vertical Suction of Pumps

Altitude	Barometric Pressure Lbs. per Sq. In.	Equivalent Head of Water Feet	Practical Suction Lift of Pumps Feet
Sea level	14.70	33.95	25
¼ mile (1320 ft.) above sea level	14.02	32.38	24
½ mile (2640 ft.) above sea level	13.33	30.79	23
¾ mile (3960 ft.) above sea level	12.66	29.24	21
1 mile (5280 ft.) above sea level	12.02	27.76	20
1¼ mile (6600 ft.) above sea level	11.42	26.38	19
1½ mile (7920 ft.) above sea level	10.88	25.13	18
2 mile (10560 ft.) above sea level	9.88	22.82	17

Barometric reading in inches multiplied by 0.4908 equals pressure per square inch.

WATER CONVERSION TABLES

1 Miner's inch = 1½ cubic feet per minute = 11.25 U. S. gallons per minute.
1 Cubic foot fresh water = 62.4 lbs. @ 53° F. = 7.48 U. S. gallons.
1 Cubic foot sea water = 64.3 lbs. approx.
1 U. S. gallon fresh water = 8.33 lbs. @ 53° F. = .1134 cubic feet.
1,000 Boiler Horse Power @ 30 pounds feed = 60 gallons per minute (approx.).

$$\text{Velocity in feet per second} = \frac{.41 \times \text{U. S. gallons per minute.}}{\text{(diameter of pipe in inches)}}$$

One Acre-foot = 325,850 U. S. gallons.

$$\text{Theoretical Water Horse Power} = \frac{\text{U. S. gallons per minute x head in feet.}}{\text{3970 (4000 approx.).}}$$

$$\text{Theoretical Water Horse Power} = \frac{\text{U. S. gallons per minute x head in pounds.}}{1720.}$$

$$\text{Brake Horse Power} = \frac{\text{Theoretical Water Horse Power.}}{\text{Pump efficiency.}}$$

1,000,000 U. S. gallons per day = 695 U. S. gallons per minute.
500 pounds per hour = 1 U. S. gallon per minute.

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Useful Information on Pumps and Pipe Lines---Cont.

CAPACITIES OF SINGLE-ACTING TRIPLEX PUMPS

Diam. Plunger Inches	LENGTH OF STROKE IN INCHES, AND CAPACITY PER REVOLUTION IN U. S. GALLONS, OF SINGLE-ACTING TRIPLEX PUMP WITH GIVEN DIAMETER																Diam. Plunger Inches
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24	
1	.0102	.020	.030	.404	.051	.061	.071	.082	.092	.102	.122	.143	.163	.184	.204	.244	1
1¼	.0159	.031	.047	.063	.079	.095	.111	.127	.143	.159	.191	.223	.254	.286	.318	.382	1¼
1½	.0229	.045	.069	.091	.114	.137	.161	.184	.206	.229	.275	.322	.367	.413	.459	.551	1½
2	.0408	.081	.122	.163	.204	.244	.285	.326	.367	.408	.489	.571	.653	.735	.816	.979	2
2½	.0637	.127	.191	.255	.318	.382	.447	.510	.574	.637	.765	.894	1.02	1.15	1.27	1.53	2½
3	.0918	.183	.276	.367	.459	.550	.642	.734	.826	.918	1.10	1.28	1.47	1.65	1.83	2.20	3
3½	.1249	.249	.374	.498	.629	.749	.875	.998	1.12	1.25	1.49	1.75	2.00	2.24	2.50	3.00	3½
4	.1632	.326	.489	.652	.816	.980	1.14	1.31	1.47	1.63	1.96	2.28	2.62	2.94	3.27	3.92	4
4½	.2065	.413	.619	.826	1.03	1.24	1.44	1.65	1.86	2.06	2.48	2.89	3.30	3.72	4.13	4.96	4½
5	.2550	.510	.765	1.02	1.27	1.53	1.78	2.04	2.30	2.55	3.06	3.57	4.08	4.59	5.10	6.12	5
5½	.3085	.617	.925	1.23	1.54	1.85	2.16	2.47	2.78	3.08	3.70	4.32	4.94	5.55	6.17	7.40	5½
6	.3672	.734	1.10	1.46	1.83	2.20	2.57	2.94	3.30	3.67	4.40	5.13	5.87	6.60	7.35	8.81	6
6½	.4308	.861	1.29	1.72	2.15	2.58	3.02	3.45	3.88	4.31	5.17	6.03	6.89	7.75	8.62	10.34	6½
7	.4998	.999	1.49	1.99	2.49	2.99	3.50	3.99	4.50	5.00	5.98	6.99	7.99	9.00	10.00	11.99	7
7½	.5737	1.14	1.72	2.29	2.86	3.44	4.02	4.58	5.16	5.74	6.88	8.03	9.17	10.32	11.47	13.77	7½
8	.6528	1.30	1.95	2.61	3.26	3.91	4.67	5.22	.587	6.53	7.83	9.14	10.44	11.74	13.05	15.66	8
8½	.7369	1.47	2.21	2.84	3.68	4.42	5.16	5.90	6.62	7.37	8.84	10.31	11.77	13.24	14.73	17.68	8½
9	.8262	1.65	2.48	3.30	4.13	4.96	5.78	6.61	7.43	8.26	9.91	11.56	13.22	14.87	16.52	19.83	9
9½	.9205	1.84	2.76	3.68	4.60	5.52	6.45	7.36	8.28	9.20	11.04	12.88	14.72	16.57	18.40	22.09	9½
10	1.020	2.04	3.06	4.08	5.10	6.12	7.14	8.16	9.18	10.20	12.24	14.28	16.32	18.36	20.40	24.48	10
11	1.234	2.46	3.70	4.93	6.17	7.40	8.64	9.87	11.10	12.34	14.81	17.28	19.74	22.21	24.68	29.62	11
12	1.468	2.93	4.40	5.87	7.34	8.81	10.28	11.75	13.21	14.69	17.62	20.56	23.50	26.42	29.38	35.25	12
13	1.723	3.44	5.17	6.89	8.61	10.34	12.06	13.78	15.51	17.24	20.68	24.12	27.57	31.02	34.47	41.36	13
14	1.998	3.99	5.99	7.99	9.99	11.98	13.99	15.99	17.99	19.98	23.97	27.97	31.97	35.96	39.96	47.95	14
15	2.293	4.58	6.88	9.17	11.46	13.74	16.05	18.34	20.64	22.94	27.52	32.11	36.79	41.28	45.87	55.04	15
16	2.610	5.22	7.83	10.44	13.05	15.66	18.27	20.88	23.49	26.10	31.32	36.54	41.76	46.98	52.20	62.64	16
17	2.947	5.89	8.84	11.79	14.74	17.69	20.62	23.58	26.53	29.47	35.37	41.25	47.16	53.06	58.95	70.75	17
18	3.303	6.60	9.90	13.21	16.52	19.82	23.12	26.42	29.72	33.03	39.64	46.24	52.85	59.45	66.06	79.27	18
19	3.682	7.36	11.04	14.72	18.41	22.09	25.78	29.46	33.14	36.82	44.19	51.55	58.91	66.28	73.64	88.37	19
20	4.080	8.16	12.24	16.32	20.40	24.48	28.56	32.64	36.72	40.80	48.96	57.12	65.28	73.44	89.76	97.92	20

NOTE—To find capacity of Single-Acting Quintuplex Pumps, multiply results in above table by 5/3.

Courtesy of The Aldrich Pump Co.

INPUT HORSE POWER NECESSARY AT VARIOUS EFFICIENCIES

(Pump and Motor Combined)

Water H. P. Desired	COMBINED EFFICIENCY—MOTOR AND PUMP—PER CENT.																Desired Water H. P.
	40	45	50	55	60	65	70	72	74	76	78	80	82	84	86	88	90	
1	2.5	2.2	2.0	1.8	1.7	1.5	1.4	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1
2	5.0	4.4	4.0	3.6	3.3	3.1	2.9	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2
3	7.5	6.7	6.0	5.4	5.0	4.5	4.3	4.2	4.1	3.9	3.8	3.8	3.7	3.6	3.5	3.4	3.3	3
4	10.0	8.9	8.0	7.2	6.7	6.2	5.7	5.6	5.4	5.3	5.1	5.0	4.9	4.8	4.7	4.5	4.4	4
5	12.5	11.1	10.0	9.0	8.3	7.7	7.1	6.9	6.8	6.6	6.4	6.3	6.1	6.0	5.8	5.7	5.6	5
10	25.0	22.3	20.0	18.2	16.7	15.4	14.3	13.9	13.5	13.1	12.8	12.5	12.2	11.9	11.6	11.4	11.1	10
20	50.0	44.4	40.0	36.4	33.3	30.8	28.6	27.8	27.0	26.3	25.7	25.0	24.4	23.8	23.3	22.7	22.2	20
30	75.0	66.7	60.0	54.6	50.0	46.2	42.8	41.7	40.6	39.5	38.5	37.5	36.6	35.7	34.9	34.1	33.3	30
40	100.0	88.9	80.0	72.7	66.7	61.6	57.2	55.6	54.1	52.6	51.3	50.0	48.8	47.6	46.5	45.4	44.4	40
50	125.0	111.2	100.0	90.8	83.3	77.0	71.5	69.4	67.6	65.8	64.2	62.5	61.0	59.5	58.2	56.8	55.6	50
60	150.0	133.3	120.0	109.1	100.0	92.3	85.7	83.3	81.1	79.0	76.9	75.0	73.2	71.4	69.8	68.2	66.7	60
70	175.0	155.5	140.0	127.3	116.7	107.7	100.0	97.2	94.6	92.2	89.7	87.5	85.3	83.3	81.4	79.5	77.8	70
80	200.0	177.7	160.0	145.4	133.3	123.1	114.3	111.2	108.2	105.3	102.5	100.0	97.6	95.3	93.1	90.8	88.9	80
90	225.0	200.0	180.0	163.6	150.0	138.5	128.6	125.0	121.6	118.5	115.3	112.5	109.7	107.2	104.6	102.3	100.0	90
100	250.0	222.2	200.0	181.8	166.7	153.7	142.8	138.9	135.1	131.6	128.2	125.0	121.9	119.1	116.3	103.7	111.2	100
125	312.5	277.5	250.0	227.3	208.5	192.3	178.6	173.6	168.8	164.3	160.3	156.2	152.4	148.8	145.3	142.0	138.9	125
150	375.0	333.2	300.0	273.0	250.0	231.0	214.5	208.5	202.7	197.4	192.3	187.5	183.0	178.6	174.4	170.4	166.7	150
175	437.5	388.8	350.0	318.0	291.5	269.0	250.0	243.0	236.7	230.1	224.5	218.5	213.5	208.5	203.5	198.8	194.4	175
200	500.0	444.0	400.0	364.0	333.0	308.0	286.0	278.0	270.0	263.0	257.0	250.0	244.0	238.0	233.0	227.0	222.0	200
225	563.0	500.0	450.0	409.0	375.0	346.0	321.7	313.0	304.0	296.0	288.0	281.0	275.0	268.0	262.0	255.0	250.0	225
250	625.0	556.0	500.0	454.0	417.0	385.0	357.0	347.0	338.0	329.0	321.0	313.0	305.0	298.0	291.0	284.0	278.0	250
300	750.0	667.0	600.0	546.0	500.0	462.0	428.0	417.0	406.0	395.0	385.0	375.0	366.0	357.0	349.0	341.0	333.0	300
350	875.0	778.0	700.0	637.0	583.0	538.0	500.0	487.0	473.0	461.0	448.0	438.0	427.0	417.0	407.0	398.0	389.0	350
400	1000.0	889.0	800.0	727.0	667.0	616.0	572.0	556.0	541.0	527.0	513.0	500.0	488.0	477.0	465.0	454.0	444.0	400
450	1125.0	1000.0	900.0	818.0	750.0	692.0	643.0	625.0	608.0	592.0	577.0	563.0	549.0	536.0	523.0	511.0	500.0	450
500	1250.0	1112.0	1000.0	908.0	833.0	770.0	715.0	694.0	676.0	658.0	641.0	625.0	610.0	595.0	582.0	568.0	556.0	500

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Useful Information on Pumps and Pipe Lines---Cont.

IMPORTANCE OF CONSIDERING THE FRICTION OF WATER IN PIPES

In estimating the total head against which a given quantity of water is to be delivered particular attention is called to the importance of considering the friction of water in pipes, elbows and valves. In writing for estimates the length and size of suction and discharge pipes, and the number of tees, ells and valves must be given.

The importance of using large enough pipes thereby saving power is illustrated as follows: 500 gallons delivered per minute through a 4-inch pipe (see friction table) means a friction head of 170.53 feet for each 1,000 feet of pipe; the same quantity delivered through an 8-inch pipe produces a friction head of but 5.64 feet per each 1,000 feet of pipe.

FRICTION OF WATER IN WROUGHT AND CAST IRON PIPES

Frictional heads at given rates of discharge in clean wrought iron pipe. (Inside Diam.) for each 100 feet of length

U. S. Gal. per Minute	U. S. Gal. per 24 Hours	¾ In. Pipe		1 In. Pipe		1¼ In. Pipe		1½ In. Pipe		2 In. Pipe		2½ In. Pipe		3 In. Pipe	
		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd	
		Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Fect	Lbs.	Feet	Lbs.
5	7200	7.59	3 30	1 93	.84	.71	.31	.27	.12						
10	14400	29.90	13.00	10 26	3.16	2.41	1 05	1 08	.47						
15	21600	66.01	28 70	16.05	6.98	5.47	2 38	2.28	.97						
20	28800	115.92	50.40	28.29	12.30	9.36	4.07	3.81	1.66						
25	36000			43.70	19.00	14.72	6.40	5 02	2 62	1.18	.51				
30	43200			68.25	27.50	21 04	9.15	8.62	3.75	2.09	.91				
35	50400			85.10	37.00	28.52	12.40	11.61	5.05	2 76	1.20				
40	57600			110.40	48.00	37.03	16.10	14.99	6.52	3.68	1.60	1.19	.52		
45	64800					46.46	20.20	18.74	8.15	4.60	2.00	1.49	.65		
50	72000					57.27	24 90	23.00	10.00	5.61	2.44	1.86	.81	.80	.85
75	108000					129.00	56.10	51.52	22.40	12.23	5 32	4 14	1 80	1.70	.74
100	144000							89.70	39 00	21.75	9.46	7.86	3.20	3.01	1.31
125	180000									34.27	14 90	11 24	4.89	4.57	1.99
150	216000									48.76	21.20	16.10	7 00	6.55	2 85
175	252000									64 63	28.10	21.75	9 46	8.85	3.85
200	288000									86.25	37.50	28.68	12.47	11.54	5.02
250	360000											45.21	19.66	17.84	7.76
300	432000											64.58	28.06	25.76	11.20
350	504000													34.96	15.20
400	576000													44.85	19.50
450	648000													57.50	25.00
500	720000													70 84	30.80

Frictional heads at given rates of discharge in clean cast iron pipes for each 1000 feet of length.

U. S. Gal. per Minute	U. S. Gal. per 24 Hours	4 In. Pipe		5 In. Pipe		6 In. Pipe		8 In. Pipe		10 In. Pipe		12 In. Pipe		14 In. Pipe	
		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd	
		Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs	Feet	Lbs.
50	72000	2.01	.87	.67	.29	.32	.14								
100	144000	7.86	3 19	2.61	1.14	1.08	.47								
125	180000	12.19	5.3.	4 07	1.77	1 68	.78								
150	216000	16.05	6 95	5.86	2.34	2 28	.99								
200	288000	28 09	12.17	10.32	4 48	3.92	1.70	1.01	.44						
250	360000	43.47	18 83	16.24	7 06	6.00	2.60	1.52	.66						
300	432000	62 20	26.94	23.40	10.20	8.52	3 69	2 13	.92	.75	.32				
400	576000	109.68	47.50	42.52	18.52	14 89	6.45	3 68	1 59	1.27	.55				
500	720000	170.58	78.87	64.90	28.20	23.01	9 97	5 64	2.44	1 93	.84	.81	.35	.40	.17
600	864000			90 20	39.80	32.89	14 25	8.03	3.48	2 72	1.18	1 14	.49	.55	.24
700	1008000			126.90	55.10	44.54	19.08	10.88	4.69	3 66	1 58	1.52	.66	.78	.32
800	1152000					57.95	25.10	14.05	6.08	4.78	2.06	1.96	.85	.94	.41
900	1296000					73.12	31.67	17 68	7 69	5 93	2.57	2.45	1.06	1.17	51
1000	1440000					90.05	38.99	21.74	9 41	7 28	3 15	3.00	1.30	1 43	62
1200	1728000							31 10	13.47	10 38	4.50	4.26	1 85	2.02	.88
1400	2016000							42 13	18 25	14 02	6 07	5 74	2.49	2.72	1 18
1600	2304000							54.84	23.75	18 22	7.89	7.44	3 22	3 51	1.52
1800	2592000							69.22	20 08	22 96	9 95	9 86	4 06	4 41	1 91
2000	2880000							85.27	36 93	28 25	12.34	11.50	5.00	5 41	2 34
2500	3600000									43 87	19 00	17 82	7.72	8.35	3 62
3000	4320000									62.92	27.25	25.51	11.05	11.98	5 17
3500	5040000											34.18	14 98	16 14	6 99
4000	5760000													21 00	9 10
4500	6480000													26.49	11 47

Frictional heads at given rates of discharge in clean cast iron pipes for each 1000 feet of length.

U. S. Gal. per Minute	U. S. Gal. per 24 Hours	16 In. Pipe		18 In. Pipe		20 In. Pipe		24 In. Pipe		30 In, pipe		36 In, Pipe		42 In. Pipe	
		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd		Friction hd	
		Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Feet	Lbs.	Fcct	Lbs.
500	720000	.22	.09												
1000	1440000	.76	.34	.44	.19										
1500	2160000	1.68	.71	.93	.40	.56	.24								
2000	2880000	2.28	1 22	1.60	.69	.96	.42	.41	.18						
2500	3600000	4.84	1.88	2.45	1.06	1.47	.64	.62	.27						
3000	4320000	6.19	2 68	3.48	1.51	2.09	.90	.87	.38	.30	.18				
3500	5040000	8.37	3.63	4.70	2.03	2.81	1 22	1.16	.50	.40	.17				
4000	5760000	10.87	4.71	6.09	2.64	3.64	1 58	1.50	.65	.52	.22				
4500	6480000	13.70	5.93	7 67	3.32	4.58	1.98	1 88	.82	.64	.28				
5000	7200000	16.85	7.30	9.43	4.08	5 62	2.43	2.31	1 00	.78	.34	.33	.14		
6000	8640000			13.49	5.84	8 03	3.48	3 28	1 42	1 11	.48	.46	.20		
7000	10080000					10.86	4.71	4.43	1.92	1 49	.65	.62	.27		
8000	11520000							5.75	2.49	1.93	.84	.80	.35		
9000	12960000							7.25	3.14	2.43	1.05	1.00	.43		
10000	14400000									2 98	1.29	1.23	.53	.63	.27
11000	15840000									3.59	1.55	1.47	.64	.76	.33
12000	17280000									4 25	1.84	1 74	.75	.91	.40
13000	18720000									4 97	2.15	2 03	.88	1 09	.47
14000	20160000									5.75	2.49	2 85	1.02	1.25	.54
15000	21600000									6.58	2.85	2 69	1.17	1.43	.62
16000	23040000											3 04	1 32	1 62	.71
17000	24480000											3 48	1.49	1 84	.80
18000	25920000											3 88	1.66	2.07	.90
20000	28800000											4 73	2.04	2 56	1.11

FRICTION FACTORS

The gradual roughening of the interior of pipe is one of the most familiar phenomena of water-piping systems. It is also one of the most difficult to compute, as it depends upon a number of different factors, the most important of which is the nature of the water carried. In a general way it may be said that in a series of years, which is not long compared with the total life of the pipe, the roughening of the inner surface and the reduction of the area through rusting and tuberculation reach such an extent that twice as much head is consumed in sending a given volume of water through it as was the case when the pipe was new.

All known coefficients of friction are based on the delivery of water much purer than mine water, usually on that supplied by city water works for domestic purposes. It is reasonable to expect greater loss of heads in piping systems handling acid and impure mine waters than in ordinary hydraulic service.

The figures given herewith are taken for clean new pipe and therefore cannot hold exactly for pipe systems after they have been in use sometime, especially in handling mine water. As a general rule, the factors 1.5, 2 and 3 may be used to multiply the figures given in the tables to get the correct figures for old pipes, very rough pipes and badly tuberculated pipes, respectively. The engineer will have to use his judgment as to condition that exists or may exist in the future.

Hydraulic Tables by Williams and Hazen may be consulted for obtaining concise information whenever needed.

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Useful Information on Pumps and Pipe Lines---Cont.

PUMP RULES

The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch, so that with a perfect vacuum it will sustain a column of mercury 29.9 inches, or a column of water 33.9 feet high at sea level.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434. Approximately, we say that every foot elevation is equal to ½ pound pressure per square inch; this allows for ordinary friction.

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston being the standard of speed), divide the number of gallons by 4, then extract the square root, and the product will be the diameter in inches of the pump cylinder.

To find quantity of water elevated in one minute running at 100 feet of piston speed per minute: Square the diameter of the water cylinder in inches and multiply by 4. Example: Capacity of a 5-inch cylinder is desired. The square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, the number of gallons per minute (approximately).

To find the horse power necessary to elevate water to a given height, multiply the weight of the water elevated per minute in pounds by the height in feet, and divide the product by 33,000 (an allowance should be added for water friction, and a further allowance for loss in steam cylinder, say from 20 to 30 per cent).

The area of the steam piston, multiplied by the steam pressure, gives the total amount of pressure that can be exerted. **The area of the water piston,** multiplied by the pressure of water per square inch, gives the resistance. **A margin** must be made between the **power** and the **resistance** to **move the** pistons at the required speed—say from 20 to 40 per cent., according to speed and other conditions.

To find the capacity of a cylinder in gallons. Multiplying the area in inches by the length of stroke in inches will give the total number of cubic inches; divide this amount by 231 (which is the cubical contents of a U. S. gallon in inches), and product is the capacity in gallons.

COMPARATIVE TABLE OF PIPE CAPACITIES

Number of Smaller Pipes Equivalent to One Larger

With the same velocity of flow, the volume delivered by two pipes of different sizes is proportional to the squares of their diameters. With the same head or pressure, however, the velocity is less in the smaller pipe and the volume delivered varies about as the square root of the 5th power. The table is calculated on this basis, the figures in each column showing the number of pipes of the size at the head of that column, equivalent in capacity to one pipe of the corresponding sizes given in side columns.

Large Pipe, Diam., Ins.	Smaller Pipes, Diameters, Inches														Large Pipe, Diam. Ins.
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	
	Number to Give Same Capacity as One Large Pipe															
2	5.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
3	15.6	2.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
4	32.0	5.7	2.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
5	55.9	9.9	3.6	1.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
6	88.2	15.6	5.7	2.8	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
7	130	22.9	8.3	4.1	2.3	1.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	7
8	181	32.0	11.7	5.7	3.2	2.1	1.4	.....	.....	.....	.....	.....	.....	.....	.....	8
9	243	43.0	15.6	7.6	4.3	2.8	1.9	1.3	.....	.....	.....	.....	.....	.....	.....	9
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	.....	.....	.....	.....	.....	.....	10
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3	.....	.....	.....	.....	.....	11
12	499	88.2	32.0	15.6	8.9	5.7	3.8	2.8	2.1	1.6	.....	.....	.....	.....	.....	12
13	609	108	39.1	19.0	10.9	7.1	4.7	3.4	2.5	1.9	1.2	.....	.....	.....	.....	13
14	733	130	47.0	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	.....	.....	.....	.....	14
15	871	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2	.....	.....	.....	15
16	....	181	65.7	32.0	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	.....	.....	.....	16
17	....	211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2	.....	.....	17
18	.....	243	82.2	43.0	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	.....	.....	18
20	.....	316	115	55.9	32.0	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	.....	20
22	.....	401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	22
24	.....	499	181	88.2	50.5	32.0	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	24

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Useful Information on Pumps and Pipe Lines---Cont.

WATER HEAD IN FEET AND EQUIVALENT PRESSURE IN POUNDS PER SQUARE INCH

Head in Feet	Equivalent Pressure in Pounds per square inch	Head in Feet	Equivalent Pressure in Pounds per square inch	Head in Feet	Equivalent Pressure in Pounds per square inch	Head in Feet	Equivalent Pressure in Pounds per square inch	Head in Feet	Equivalent Pressure in Pounds per square inch
1	0.43	64	27.72	127	55.01	189	81.87	1475	638.68
2	0.86	65	28.15	128	55.44	190	82.80	1500	649.50
3	1.30	66	28.58	129	55.88	191	82.73	1525	660.33
4	1.73	67	29.02	130	56.31	192	83.17	1550	671.15
5	2.16	68	29.45	131	56.74	193	83.60	1575	681.98
6	2.59	69	29.88	132	57.18	194	84.03	1600	692.80
7	3.03	70	30.32	133	57.61	195	84.47	1625	703.63
8	3.46	71	30.75	134	58.04	196	84.90	1650	714.45
9	3.89	72	31.18	135	58.48	197	85.33	1675	725.28
10	4.33	73	31.62	136	58.91	198	85.76	1700	736.10
11	4.76	74	32.05	137	59.34	199	86.20	1725	746.93
12	5.20	75	32.48	138	59.77	200	86.60	1750	757.75
13	5.63	76	32.92	139	60.21	225	97.43	1775	768.58
14	6.06	77	33.35	140	60.64	250	108.25	1800	779.40
15	6.49	78	33.78	141	61.07	275	119.08	1825	790.23
16	6.93	79	34.21	142	61.51	300	129.90	1850	801.05
17	7.36	80	34.65	143	61.94	325	140.73	1875	811.88
18	7.79	81	35.08	144	62.37	350	151.55	1900	822.70
19	8.22	82	35.52	145	62.81	375	162.38	1925	833.53
20	8.66	83	35.95	146	63.24	400	173.20	1950	844.35
21	9.09	84	36.39	147	63.67	425	184.03	1975	855.18
22	9.53	85	36.82	148	64.10	450	194.85	2000	866.00
23	9.96	86	37.25	149	64.54	475	205.68	2025	876.83
24	10.39	87	37.68	150	64.97	500	216.50	2050	887.65
25	10.82	88	38.12	151	65.40	525	227.33	2075	898.48
26	11.26	89	38.55	152	65.84	550	238.15	2100	909.30
27	11.69	90	38.98	153	66.27	575	248.98	2125	920.13
28	12.12	91	39.42	154	66.70	600	259.80	2150	930.95
29	12.55	92	39.85	155	67.14	625	270.63	2175	941.78
30	12.99	93	40.28	156	67.57	650	281.45	2200	952.60
31	13.42	94	40.72	157	68.0	675	292.28	2225	963.43
32	13.86	95	41.15	158	68.43	700	303.10	2250	974.25
33	14.29	96	41.58	159	68.87	725	313.93	2275	985.08
34	14.72	97	42.01	160	69.31	750	324.75	2300	995.90
35	15.16	98	42.45	161	69.74	775	335.58	2325	1006.73
36	15.59	99	42.88	162	70.17	800	346.40	2350	1017.55
37	16.02	100	43.31	163	70.61	825	357.23	2375	1028.38
38	16.45	101	43.75	164	71.04	850	368.05	2400	1039.20
39	16.89	102	44.18	165	71.47	875	378.88	2425	1050.03
40	17.32	103	44.61	166	71.91	900	389.70	2450	1060.85
41	17.75	104	45.05	167	72.34	925	400.53	2475	1071.68
42	18.19	105	45.48	168	72.77	950	411.35	2500	1082.50
43	18.62	106	45.91	169	73.20	975	422.18	2525	1093.33
44	19.05	107	46.34	170	73.64	1000	433.00	2550	1104.15
45	19.49	108	46.78	171	74.07	1025	433.83	2575	1114.98
46	19.92	109	47.21	172	74.50	1050	454.65	2600	1125.80
47	20.35	110	47.64	173	74.94	1075	465.48	2625	1136.63
48	20.79	111	48.08	174	75.37	1100	476.30	2650	1147.45
49	21.22	112	48.51	175	75.80	1125	487.13	2675	1158.28
50	21.65	113	48.94	176	76.23	1150	497.95	2700	1169.10
51	22.09	114	49.38	177	76.67	1175	508.78	2725	1179.93
52	22.52	115	49.81	178	77.10	1200	519.60	2750	1190.75
53	22.95	116	50.24	179	77.53	1225	530.43	2775	1201.58
54	23.39	117	50.68	180	77.97	1250	541.25	2800	1212.40
55	23.82	118	51.11	181	78.40	1275	552.08	2825	1223.23
56	24.26	119	51.54	182	78.84	1300	562.90	2850	1234.05
57	24.69	120	51.98	183	79.27	1325	573.73	2875	1244.88
58	25.12	121	52.41	184	79.70	1350	584.55	2900	1255.70
59	25.55	122	52.84	185	80.14	1375	595.38	2925	1266.53
60	25.99	123	53.28	186	80.57	1400	606.20	2950	1277.35
61	26.42	124	53.71	187	81.0	1425	617.03	2975	1288.18
62	26.85	125	54.[illegible]	188	81.43	1450	627.85	3000	1299.00
63	27.29	126	54.[illegible]						

STANDARD WROUGHT PIPE*

Dimensions, Threads, Areas and Weights

Diaeter, Inches: Nominal Inside	Actual: Outside	Actual: Inside	Number of Thirds, per Inch	Lgth. of Perfect Thread, Inches	Internal Area, Square Inches	Length, Containing One Square Foot of Internal	Surface, Feet Weight, Lbs. per Lineal Foot
1/8	.405	.269	27	.19	.057	170.388	.24
1/4	.540	.364	18	.29	.104	125.916	.42
3/8	.675	.493	18	.30	.191	92.964	.57
1/2	.840	.622	14	.39	.304	73.692	.85
3/4	1.050	.824	14	.40	.533	55.620	1.13
1	1.315	1.049	11 1/2	.51	.864	43.692	1.68
1 1/4	1.660	1.380	11 1/2	.54	1.495	33.204	2.27
1 1/2	1.900	1.610	11 1/2	.55	2.036	28.464	2.71
2	2.375	2.067	11 1/2	.58	3.355	22.164	3.65
2 1/2	2.875	2.469	8	.89	4.788	18.564	5.79
3	3.500	3.068	8	.95	7.393	14.940	7.57
3 1/2	4.000	3.547	8	1.00	9.886	12.912	9.11
4	4.500	4.026	8	1.05	12.730	11.376	10.79
4 1/2	5.000	4.506	8	1.10	15.947	10.164	12.54
5	5.563	5.047	8	1.16	20.006	9.072	14.61
6	6.625	6.065	8	1.26	28.891	7.548	18.97
7	7.625	7.023	8	1.36	38.738	6.516	23.54
8	8.625	7.981	8	1.46	50.027	5.736	28.55
9	9.625	8.941	8	1.57	62.786	5.124	33.91
10	10.750	10.020	8	1.68	78.855	4.572	40.48
11	11.750	11.000	8	1.78	95.033	4.164	45.56
12	12.750	12.000	8	1.88	113.097	3.816	49.56
13	14.000	13.250	8	2.09	137.881	3.456	54.57
14	15.000	14.250	8	2.10	159.487	3.216	58.57
15	16.000	15.250	8	2.20	182.656	170.388	62.58

*Goodman Mining Handbook.

EXTRA STRONG WROUGHT PIPE*

Dimensions, Areas and Weights

Diameter, Inches: Nominal Inside	Actual: Outside	Actual: Inside	Internal Area, Square Inches	Length Containing One Square Foot of Internal Surface, Feet	Length Containing One Cubic Foot, Feet	Weight, Lbs. per Lineal Foot
1/8	.405	.215	.036	213.192	3966.39	.314
1/4	.540	.302	.072	151.776	2010.29	.535
3/8	.675	.423	.141	108.360	1024.69	.738
1/2	.840	.546	.234	83.940	615.02	1.087
3/4	1.050	.742	.433	61.764	333.02	1.473
1	1.315	.957	.719	47.892	200.10	2.171
1 1/4	1.660	1.278	1.283	35.856	112.26	2.996
1 1/2	1.900	1.500	1.767	30.552	81.49	3.631
2	2.375	1.939	2.953	23.628	48.77	5.022
2 1/2	2.875	2.323	4.238	19.728	33.98	7.661
3	3.500	2.900	6.605	15.804	21.80	10.252
3 1/2	4.000	3.364	8.888	13.620	16.20	12.505
4	4.500	3.826	11.497	11.976	12.53	14.983
4 1/2	5.000	4.290	14.455	10.680	9.96	17.611
5	5.563	4.813	18.194	9.516	7.92	20.778
6	6.625	5.761	26.067	7.956	5.52	28.573
7	7.625	6.625	34.472	6.912	4.18	38.048
8	8.625	7.625	45.663	6.000	3.15	43.388
9	9.625	8.625	58.426	5.304	2.46	48.728
10	10.750	9.750	74.662	4.692	1.93	54.735
11	11.750	10.750	90.763	4.260	1.59	60.075
12	12.750	11.750	108.434	3.900	1.33	65.415

*Goodman Mining Handbook,

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Useful Information on Pumps and Pipe Lines---Cont.

FLOW OF WATER IN PIPES

From "Book of Standards," (National Tube Company) 1913 Edition, Pages 277, 278, and 279.

The quantity of water discharged through a pipe depends on the head. If the discharge occurs freely into the air, this head is the difference in level between the surface of the water in the reservoir and the center of the discharge end of the pipe; if the lower end of the pipe is submerged, the head is the difference in elevation between the two water levels. The discharge for a given diameter depends also upon the length of the pipe, upon the character of its interior surface as to smoothness and upon the number and sharpness of its bends.

The head, instead of being an actual distance between levels, may be caused by pressure, as by pumping, in which case the head is calculated as a vertical distance corresponding to the pressure, 1 pound per square inch being equal to 2.309 feet head, or 1 foot head being equal to a pressure of 0.433 pound per square inch.

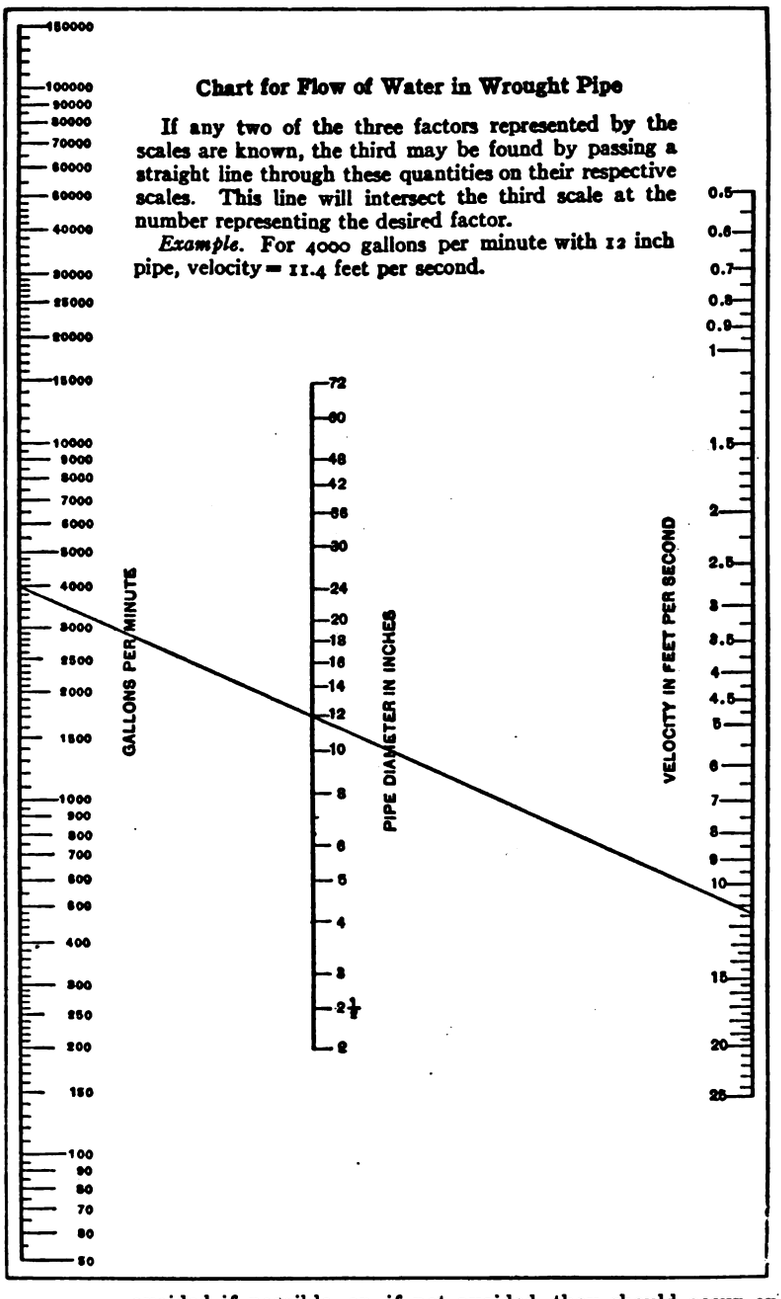
The total head operating to cause flow is divided into three parts: (1) the velocity head, which is the height through which a body must fall in a vacuum to acquire the velocity with which the water flows in the pipe. This is equal to $v^2 \div 2g$, in which v is the velocity in feet per second, and $2g = 64.32$. (2) The entry head, which is required to overcome the resistance to entrance to the pipe. With sharp-edged entrance the entry head equals about one-half of the velocity head; with smooth, rounded entrance the entry head is inappreciable; (3) the friction head, due to the frictional resistance to flow in the pipe.

In ordinary cases of pipes of considerable length the sum of the entry and velocity heads scarcely exceeds one foot; in the case of long pipes with low heads it is so small that it may be neglected.

When the flow becomes steady, the pipe is entirely filled throughout its length, and hence the mean velocity at any section is the same as that at the end, when the size is uniform. This velocity is found to decrease as the length of the pipe increases, other things being equal, and becomes very small for great lengths, which shows that nearly all the head has been lost in overcoming the resistances. The length of the pipe is measured along its axis, following all the curves, if there be any. The velocity considered is the mean velocity, which is equal to the discharge divided by the area of the cross section of the pipe. The actual velocities in the cross section are greater than this mean velocity near the center and less than it near the interior surface of the pipe.

The object of the discussion of flow in pipes is to enable the discharge which will occur under given conditions to be determined, or to ascertain the proper size which a pipe should have in order to deliver a given discharge. The subject cannot, however, be developed with the definiteness which characterizes the flow from orifices and weirs, partly because the condition of the interior surface of the pipe greatly modifies the discharge, partly because of the lack of experimental data, and partly on account of defective theoretical knowledge regarding the laws of flow. In orifices and weirs errors of two or three per cent may be regarded as large with careful work; in pipes such errors are common and are generally exceeded in most practical investigations.

It fortunately happens, however, that in most cases of the design of systems of pipes errors of five and ten per cent are not important, although they are of course to be avoided if possible, or, if not avoided, they should occur on the side of safety.



Quantity of Water Discharged

The quantity of water which flows through a pipe is the product of the area of its cross section and the mean velocity of flow. That is,

$$Q = av,$$

in which Q is the quantity discharged in cubic feet per second, a is the area in square feet and v is the velocity in feet per second.

For U. S. gallons per second multiply by 7.4805
For U. S. gallons per minute multiply by 448.83
For U. S. gallons per hour multiply by 26929.9
For U. S. gallons per 24 hours multiply by 646317.

The diagram above gives the discharge in gallons per minute when the velocity in the pipe line is known.

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FORMULAS FOR PUMPS AND PIPING

TO FIND	GIVEN	FORMULAS
1—Pressure in lb. per sq. in. = P	Head in ft. = H	$P = H \times 0.433$
2—Head in feet = H	Pressure in lb. per sq. in. = P	$H = P \times 2.312$
3—Horsepower required to raise water (theoretical)	Gals. per min. = G Head in ft. = H	$HP = \frac{G \times H}{33{,}000}$
4—Volume of water discharged by pipe (neglecting bends and friction)	Internal diam. of pipe in in. = D Head in ft. = H Length of pipe in yds. = L	Gals. per min. $= \sqrt{\frac{D^5 \times H}{L}}$
5—Theoretical capacity of single-acting pump	Area of ram in sq. in. = A Stroke in in. = S No. of strokes per min. = N	Gals. per min. $= \frac{A \times S \times N \times 62.5}{1728}$
6—Diam. in in. of single-acting pump to deliver given number of gals. per stroke	Gal. per stroke = G Stroke in feet = S	Diameter of pump $= \sqrt{\frac{31\,G}{S}}$ (Allowing 5 per cent. waste)
7—Feet head lost by friction in pipes = F	Gal. per min. = G Length of pipe in yds. = L Internal diam. of pipe in in. = D	$F = \frac{G^2 \times L}{(3\,D)^5}$
8—Approx. weight of water in vertical pipes in lb. = W	Internal diam. of pipe in in. = D Length of pipe in yds. = L	$W = D^2 \times L$
9—Thickness of cast-iron pipes in in. = T	Internal diam. of pipe in in. = D Pressure in lb. per sq. in. = P	$T = \frac{D \times P}{4000} + 0.3$
10—Delivery per stroke of single-acting pump.	Diam. of plunger in in. = D Stroke in feet = S	Gal. delivered per stroke $= \frac{D^2 \times S}{31}$ (Allowing 5 per cent. waste)
11—Speed of water through pipes in ft. per sec.	Area of pipe in sq. in. = A Discharge in cu. ft. per min. = F.P.M.	Velocity ft. per sec. $= \frac{F.P.M. \times 2.4}{A}$
12—Velocity in ft. per sec. due to head = V	H = Head g = 32.2 = Gravity	$V = \sqrt{2gH}$
13.—Head from velocity	.....	$H = \frac{V^2}{2g}$
14—Imperial gallons	Cubic feet = C	Imperial gallons = C x 62.5
15—Cubic feet	Gallons (Imperial) = G	Cubic feet = G x 0.16

G. S. Burrows in American Machinist, 1912.

Useful Figures and Formulae—Water

1 cubic foot of water = ... 62.3791 lbs.
1 cubic inch of water = ... .03612 lbs.
1 gallon of water = ... 8.338 lbs.
1 gallon of water = ... 231. cubic in.
1 cubic foot of water = ... 7.476 gallons

1 pound of water = ... 27.7 cubic in.
P=pressure per lbs. per sq. in.....P=Hx .4335
H = head of water in feet.....H=Px2.307
Pressure per square foot = ...Hx 62.425

The above data are calculated for distilled water at 40 degrees Fahrenheit.

To compute the horse-power necessary to raise water to any height: Multiply the gallons per minute by 8.33. Multiply this product by the feet lift. The result is **foot-pounds.** Divide by 33,000 to reduce to horse-power per minute. (An allowance of 25 per cent should be made for friction, etc.)

To compute the capacity of pumping engines, multiply the area of the water piston, in inches, by the distance it travels, in inches, in a given time. The product divided by 231 gives number of gallons in time named.

To find the capacity of a cylinder in gallons, multiply the area, in inches, by the length of stroke, in inches, which will give the total number of cubic inches; divide this product by 231 (which is the cubical contents of a gallon in inches), and quotient is capacity in gallons. Ordinary speed to run pumps is 100 feet of piston travel per minute.

To find quantity of water elevated in one minute, running at one hundred feet of piston travel per minute, square the diameter of water cylinder and multiply by 4. Example: If the capacity of a 5-inch cylinder is desired, the square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, which is gallons per minute (approximately).

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston travel being the speed), divide the number of gallons by 4, then extract the square root, which will be the required diameter in inches.

To find the velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144, and divide the product by the area of the pipe in inches.

To find the area of a required pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144, and divide the product by the velocity in feet per minute. The area being found, it is easy to get the diameter of pipe necessary.

—American Steam Pump Company.

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APPROXIMATE CU. FT. OF FREE AIR AND WORKING PRESSURE REQUIRED TO RAISE 1 GAL. OF WATER BY AIR LIFT

$$V = \frac{L}{\log \frac{H+34}{34} \times 292.5}$$

H = Submergence in Feet.
L = Lift in Feet.

Ft. Lb. = Working Power = Submergence x 0.4465 + 7 Lbs.
V = Volume of Free Air per Gallon in Cubic Feet.

Ratio of Submergence to Lift

Lift in Feet	25 Per Cent ⅓—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	33 Per Cent ½—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	43 Per Cent ¾—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	50 Per Cent 1—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	Stage
20										0.34	16	.018	ONE STAGE
30										0.38	20	.024	
40										0.41	25	.031	
50										0.44	29	.036	
60										0.47	34	.043	
80										0.52	43	.056	
100							0.68	40	.070	0.58	52	.071	
120							0.73	47	.084	0.63	61	.075	TWO STAGE
140							0.79	54	.099	0.68	70	.087	
160							0.84	61	.100	0.73	78	.099	
180							0.88	67	.110	0.77	88	.111	
200	1.44	37	.141	1.15	52	.141	0.93	74	.123	0.82	96	.124	
250	1.57	44	.172	1.27	63	.154	1.05	91	.154	0.92	119	.154	
300	1.69	52	.207	1.40	74	.186	1.20	107	.191	1.03	141	.187	
350	1.82	59	.241	1.50	85	.213	1.31	124	.224	1.16	163	.225	
400	1.96	66	.244	1.63	96	.246	1.38	141	.250	1.23	186	.253	
450	2.08	74	.276	1.74	107	.277	1.48	157	.282	1.33	208	.267	THREE STAGE
500	2.19	82	.306	1.86	119	.312	1.56	174	.312	1.43	230	.299	
550	2.30	88	.333	1.96	130	.342	1.68	191	.349	1.52	253	.329	
600	2.41	96	.364	2.05	141	.372	1.78	208	.358	1.61	275	.360	
650	2.52	104	.396	2.18	152	.409	1.87	226	.388	1.74	297	.400	
700	2.64	111	.428	2.27	163	.441	1.96	240	.416	1.81	320	.427	
750	2.76	119	.463	2.37	174	.473	2.06	258	.450	1.88	342	.454	
800	2.88	126	.496	2.47	186	.508	2.15	275	.480	1.97	364	.486	
850	2.97	133	.524	2.57	197	.542	2.24	292	.512	2.06	387	.519	
900	3.07	141	.557	2.67	208	.537	2.33	308	.542	2.14	409	.550	
950	3.18	149	.591	2.76	219	.566	2.40	325	.567	2.22	431	.579	
1000	3.28	156	.622	2.86	230	.598	2.77	342	.609	2.31	453	.614	

Lift in Feet	55 Per Cent 1¼—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	60 Per Cent 1½—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	66 Per Cent 2—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	70 Per Cent 2⅓—1 Free Air, Cu. Ft.	Working Pressure	Horsepower	Stage
20	0.29	18	.017	0.25	20	.016	0.20	25	.015	0.17	29	.014	ONE STAGE
30	0.32	24	.023	0.28	27	.022	0.23	34	.021	0.20	40	.021	
40	0.35	29	.029	0.31	34	.029	0.26	43	.028	0.23	52	.028	
50	0.38	35	.036	0.34	40	.035	0.29	52	.035	0.26	63	.032	TWO STAGE
60	0.41	40	.042	0.37	47	.042	0.32	61	.038	0.28	74	.037	
80	0.46	52	.056	0.42	61	.050	0.36	78	.049	0.33	96	.050	
100	0.51	63	.062	0.47	74	.062	0.41	96	.062	0.37	119	.062	
120	0.56	74	.074	0.52	87	.075	0.46	114	.076	0.42	141	.076	
140	0.61	85	.087	0.56	101	087	0.50	132	.088	0.46	163	.089	
160	0.66	96	.100	0.60	114	.099	0.54	150	.101	0.50	186	.103	
180	0.70	108	.112	0.65	127	.112	0.58	168	.114	0.54	208	.109	THREE STAGE
200	0.74	119	.124	0.69	141	.125	0.62	186	.127	0.58	230	.121	
250	0.86	147	.159	0.79	174	.158	0.72	230	.151	0.67	286	.152	
300	0.96	174	.192	0.89	208	.179	0.81	275	.181	0.76	342	.184	
350	1.05	202	.209	0.98	241	.209	0.89	320	.211	0.84	398	.214	
400	1.14	230	.238	1.08	275	.241	0.98	364	.242	0.93	453	.247	
450	1.23	258	.269	1.17	308	.272	1.07	409	.275	1.02	509	.282	
500	1.32	286	.299	1.26	342	.304	1.15	453	.306	1.09	565	.308	
550	1.42	328	.338	1.34	375	.334	1.25	498	.343				
600	1.51	342	.365	1.42	409	.365	1.31	543	.369				
650	1.61	370	.400	1.52	442	.401	1.39	587	.402				
700	1.68	398	.428	1.60	476	.432	1.47	632	.435				
750	1.78	425	.463	1.66	509	.458	1.55	677	.468				
800	1.86	453	.494	1.75	543	.493	1.65	721	.507				
850	1.93	481	.523	1.82	576	.523	1.70	766	.533				
900	2.00	509	.552	1.86	610	.544	1.77	811	.564				
950	2.08	536	.584	1.99	643	.591	1.85	855	.599				
1000	2.17	565	.618	2.06	677	.622	1.93	900	.634				

Sullivan Machinery Company's Catalog.

PIPE

Nominal inside diameter	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5
Pipe outside diam., inches	.840	1.050	1.315	1.660	1.9	2.375	2.875	3.5	4.0	4.5	5.	5.563
Weight, per ft. lbs	.837	1.115	1.668	2.244	2.678	3.609	5.739	7.536	9.001	10.665	12.34	14.502
Threads, per inch	14	14	11½	11½	11½	11½	8	8	8	8	8	8
Fittings, lbs. per 100												
Bushings, C. I.	5	12	25	40	55	73	105	165	125	300	350	400
Caps, Malleable	14	22	32	56	75	120	194	300	315	445	....	740
Cocks, all Iron	125	150	250	500	750	1150	2000	3000	4300	5700	....	12400
Crosses, C. I.	70	100	150	238	350	530	785	1100	1550	2150	2700	3000
Elbows, Cast	40	55	93	152	192	318	500	700	920	1250	1600	2100
Elbows, 45° Cast	37	55	84	138	196	284	440	660	850	1125	1450	1650
Flange Unions, Cast	175	225	270	390	520	612	940	1200	1475	1725	2140	2525
Plugs	10	16	29	41	52	93	149	189	283	296	460	570
Reducers	18	25	35	67	87	145	260	400	550	675	1000	1325
Tees, Cast	53	81	122	200	268	430	650	1000	1325	1780	2330	2620
Union Couplings, Malleable	48	76	95	125	147	263	400	500	781	881	....	....
Valves, Brass Gate	117	173	254	358	513	804	1310	1800	....	....	....	....
" I. B. Gate	....	....	....	....	....	3300	3700	4700	6000	7400	8900	9700
" Brass Globe	94	147	236	350	490	752	1116	1840	2280	3025	....	....
" I. B. Globe	....	....	....	....	....	2500	3000	4200	5500	6800	8000	11400

(NOTE—In above table pipe is Standard W. I. and fittings are screwed.)

Courtesy Fraser & Chalmers Co.

Economical velocity of water forced through pipe 4 ft. per second approximately.

Economical velocity of compressed air forced through pipe 25 ft. to 50 ft. per second approximately.

Economical velocity of steam forced through pipe 100 ft. per second approximately.

Doubling the diameter of a pipe increases its capacity four times. Friction of water in pipes increases with the square of its velocity.

To find the pressure of any number of square inches for a column of water, multiply the height of the column in feet by .434.

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Flow of Water in Second-Feet, and Velocity in Feet per Second in Wood Stave Pipe in Good Condition Having Ordinarily Smooth Alignment and Profile Based on the Formula*

$$H = \frac{7.68\ V^{1.8}}{d^{1.17}}$$

H = friction head per 1,000 feet.
V = velocity in feet per second.
d = diameter of pipe in inches.

Diameter in Inches	Diameter in Feet	Area, Sq. Feet	Friction head, in feet, per 1,000 feet length of pipe																					
			0.2		0.3		0.4		0.5		0.6		0.7		0.8		0.9		1.0		1.2		1.4	
			Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.
6	0.500	0.196	0.08	0.41	0.10	0.51	0.12	0.61	0.14	0.71	0.15	0.76	0.17	0.87	0.18	0.92	0.19	0.97	0.20	1.02	0.22	1.12	0.24	1.22
8	0.667	0.349	0.18	0.52	0.22	0.63	0.26	0.75	0.30	0.86	0.33	0.95	0.36	1.03	0.38	1.09	0.41	1.17	0.43	1.23	0.48	1.38	0.52	1.49
10	0.833	0.545	0.32	0.59	0.40	0.74	0.47	0.86	0.53	0.97	0.59	1.08	0.64	1.17	0.69	1.27	0.74	1.36	0.78	1.43	0.87	1.60	0.95	1.74
12	1.000	0.785	0.52	0.66	0.65	0.83	0.76	0.97	0.87	1.11	0.96	1.22	1.04	1.32	1.12	1.43	1.20	1.53	1.27	1.62	1.41	1.79	1.53	1.95
14	1.167	1.069	0.78	0.73	0.98	0.92	1.15	1.08	1.30	1.22	1.44	1.35	1.57	1.47	1.69	1.58	1.81	1.69	1.91	1.79	2.12	1.98	2.31	2.16
16	1.333	1.396	1.12	0.80	1.40	1.00	1.64	1.17	1.86	1.33	2.05	1.47	2.24	1.60	2.41	1.73	2.57	1.84	2.73	1.96	3.02	2.16	3.29	2.36
18	1.500	1.767	1.53	0.87	1.91	1.08	2.24	1.27	2.54	1.44	2.81	1.59	3.06	1.73	3.29	1.86	3.51	1.99	3.73	2.11	4.12	2.33	4.49	2.54
20	1.667	2.182	2.02	0.93	2.53	1.16	2.96	1.36	3.35	1.54	3.71	1.70	4.04	1.85	4.35	1.99	4.65	2.13	4.93	2.26	5.45	2.50	5.94	2.72
22	1.833	2.640	2.60	0.98	3.25	1.23	3.81	1.44	4.32	1.64	4.78	1.81	5.20	1.97	5.60	2.12	5.98	2.27	6.34	2.40	7.02	2.66	7.64	2.89
24	2.000	3.142	3.27	1.04	4.09	1.30	4.80	1.53	5.44	1.73	6.02	1.92	6.55	2.08	7.06	2.25	7.53	2.40	7.99	2.54	8.84	2.81	9.63	3.06
26	2.167	3.687	4.04	1.10	5.06	1.37	5.94	1.61	6.72	1.82	7.44	2.02	8.10	2.20	8.72	2.36	9.31	2.53	9.87	2.68	10.9	2.96	11.9	3.23
28	2.333	4.276	4.92	1.15	6.16	1.44	7.23	1.69	8.18	1.91	9.05	2.12	9.86	2.31	10.6	2.48	11.3	2.64	12.0	2.81	13.3	3.11	14.5	3.39
30	2.500	4.909	5.91	1.20	7.40	1.51	8.68	1.77	9.82	2.00	10.9	2.22	11.8	2.40	12.7	2.59	13.6	2.77	14.4	2.93	16.0	3.26	17.4	3.54
32	2.667	5.585	7.01	1.25	8.78	1.57	10.3	1.84	11.7	2.09	12.9	2.31	14.0	2.51	15.1	2.70	16.1	2.88	17.1	3.06	18.9	3.38	20.6	3.69
34	2.833	6.305	8.23	1.30	10.30	1.63	12.1	1.92	13.7	2.17	15.1	2.40	16.5	2.62	17.8	2.82	19.0	3.01	20.1	3.19	22.2	3.52	24.2	3.84
36	3.000	7.069	9.57	1.35	12.0	1.70	14.1	1.99	15.9	2.25	17.6	2.49	19.2	2.72	20.7	2.93	22.1	3.13	23.4	3.31	25.9	3.66	28.2	3.99
38	3.167	7.876	11.0	1.40	13.8	1.75	16.2	2.06	18.4	2.34	20.3	2.58	22.1	2.81	23.9	3.03	25.5	3.24	27.0	3.43	29.9	3.80	32.5	4.13
40	3.333	8.727	12.7	1.46	15.9	1.82	18.6	2.13	21.1	2.42	23.3	2.67	25.4	2.91	27.3	3.13	29.2	3.35	30.9	3.54	34.2	3.92	37.3	4.27
42	3.500	9.621	14.4	1.50	18.0	1.87	21.2	2.20	24.0	2.49	26.5	2.75	28.9	3.00	31.1	3.23	33.2	3.45	35.2	3.66	38.9	4.04	42.4	4.41
44	3.667	10.56	16.3	1.54	20.4	1.93	23.9	2.26	27.1	2.57	30.0	2.84	32.7	3.10	35.2	3.33	37.6	3.56	39.8	3.77	44.0	4.17	48.0	4.55
46	3.833	11.54	18.3	1.59	23.0	1.99	26.9	2.33	30.5	2.64	33.7	2.92	36.7	3.18	39.6	3.43	42.2	3.66	44.8	3.88	49.6	4.30	54.0	4.68
48	4.000	12.57	20.5	1.63	25.7	2.05	30.2	2.40	34.1	2.71	37.8	3.01	41.1	3.27	44.3	3.52	47.3	3.76	50.1	3.99	55.5	4.42	60.4	4.81
50	4.167	13.64	22.9	1.68	28.6	2.10	33.6	2.46	38.0	2.79	42.1	3.09	45.8	3.36	49.4	3.62	52.7	3.87	55.9	4.10	61.8	4.53	67.3	4.94
52	4.333	14.75	25.4	1.72	31.8	2.16	37.3	2.53	42.2	2.86	46.8	3.17	50.9	3.45	54.8	3.72	58.5	3.97	62.0	4.20	68.6	4.65	74.7	5.07
54	4.500	15.90	28.0	1.76	35.1	2.21	41.2	2.59	46.6	2.93	51.6	3.24	56.2	3.53	60.5	3.80	64.6	4.06	68.5	4.31	75.8	4.77	82.6	5.19
56	4.667	17.10	30.9	1.81	38.7	2.26	45.4	2.65	51.3	3.00	56.8	3.32	61.9	3.62	66.6	3.89	71.1	4.16	75.4	4.41	83.5	4.88	90.9	5.32
58	4.883	18.35	33.9	1.85	42.4	2.31	49.8	2.71	56.3	3.07	62.3	3.40	67.9	3.70	73.1	3.98	78.1	4.26	82.8	4.51	91.6	4.99	99.8	5.44
60	5.000	19.64	37.1	1.89	46.4	2.36	54.5	2.78	61.6	3.14	68.2	3.47	74.3	3.78	80.0	4.07	85.4	4.35	90.6	4.61	100	5.09	109	5.55
66	5.5	23.76	47.7	2.01	59.9	2.52	70.1	2.95	79.4	3.34	87.8	3.70	95.6	4.02	103	4.34	110	4.63	117	4.92	129	5.43	141	5.93
72	6.0	28.27	60.1	2.13	75.3	2.66	88.3	3.12	99.9	3.53	111	3.93	120	4.24	130	4.60	138	4.88	147	5.20	162	5.73	177	6.26
78	6.5	33.18	74.3	2.24	93.0	2.80	109	3.29	124	3.74	137	4.13	149	4.49	160	4.82	171	5.15	182	5.48	201	6.06	219	6.60
84	7.0	38.48	90.4	2.35	113	2.94	133	3.46	150	3.90	166	4.31	181	4.70	195	5.07	208	5.41	221	5.74	244	6.34	266	6.91
90	7.5	44.18	109	2.47	136	3.08	159	3.60	181	4.10	200	4.53	218	4.93	234	5.30	250	5.66	265	6.00	293	6.63	320	7.24
96	8.0	50.26	129	2.57	161	3.20	189	3.76	214	4.26	237	4.71	258	5.13	278	5.53	297	5.91	315	6.27	348	6.92	379	7.54
102	8.5	56.74	151	2.66	189	3.33	222	3.91	252	4.44	278	4.90	303	5.34	326	5.75	349	6.15	370	6.52	409	7.21	445	7.84
108	9.0	63.62	176	2.77	220	3.46	259	4.07	293	4.61	324	5.09	353	5.55	380	5.97	406	6.38	430	6.76	476	7.48	518	8.14
114	9.5	70.88	203	2.86	254	3.58	298	4.21	338	4.77	374	5.28	407	5.74	438	6.18	468	6.60	496	7.00	549	7.75	598	8.44
120	10.0	78.54	233	2.97	291	3.71	342	4.35	387	4.93	428	5.45	466	5.93	502	6.39	536	6.82	568	7.23	629	8.01	685	8.72

Diameter in Inches	Friction head, in feet, per 1,000 feet length of pipe											
	1.6		1.8		2.0		2.5		3.0		4.0	
	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.
6	0.26	1.32	0.28	1.43	0.30	1.53	0.34	1.73	0.37	1.88	0.44	2.24
8	0.56	1.60	0.60	1.72	0.64	1.83	0.72	2.06	0.80	2.29	0.94	2.69
10	1.02	1.87	1.09	2.00	1.15	2.11	1.31	2.40	1.44	2.64	1.69	3.10
12	1.65	2.10	1.76	2.24	1.87	2.38	2.12	2.70	2.34	2.98	2.75	3.50
14	2.49	2.33	2.65	2.48	2.81	2.63	3.18	2.97	3.52	3.29	4.13	3.86
16	3.54	2.54	3.78	2.71	4.01	2.87	4.54	3.25	5.02	3.60	5.89	4.22
18	4.84	2.74	5.16	2.92	5.48	3.10	6.20	3.51	6.86	3.88	8.04	4.55
20	6.40	2.93	6.83	3.13	7.24	3.32	8.19	3.75	9.07	4.16	10.6	4.86
22	8.23	3.12	8.79	3.33	9.32	3.53	10.5	3.98	11.7	4.43	13.7	5.19
24	10.4	3.31	11.1	3.53	11.7	3.72	13.3	4.23	14.7	4.68	17.2	5.47
26	12.8	3.47	13.7	3.71	14.5	3.93	16.4	4.45	18.2	4.94	21.3	5.78
28	15.6	3.65	16.7	3.90	17.7	4.14	20.0	4.68	22.1	5.17	25.9	6.06
30	18.7	3.81	20.0	4.07	21.2	4.32	24.0	4.89	26.5	5.40	31.1	6.34
32	22.2	3.98	23.7	4.24	25.2	4.51	28.5	5.10	31.5	5.64	37.0	6.62
34	26.1	4.14	27.9	4.42	29.5	4.68	33.4	5.30	37.0	5.87	43.4	6.88
36	30.4	4.30	32.4	4.58	34.4	4.87	38.9	5.50	43.0	6.08	50.5	7.14
38	35.0	4.44	37.4	4.75	39.7	5.04	44.9	5.70	49.7	6.31	58.3	7.40
40	40.1	4.60	42.9	4.92	45.4	5.20	51.4	5.89	56.9	6.52	66.8	7.65
42	45.7	4.75	48.8	5.07	51.7	5.37	58.5	6.08	64.8	6.73	76.0	7.90
44	51.7	4.90	55.2	5.23	58.5	5.54	66.2	6.27	73.3	6.94	85.9	8.13
46	58.1	5.03	62.1	5.38	65.8	5.70	74.5	6.46	82.4	7.14	96.7	8.38
48	65.1	5.18	69.5	5.53	73.7	5.86	83.4	6.64	92.2	7.34	108	8.60
50	72.5	5.32	77.4	5.68	82.1	6.02	92.9	6.81	103	7.55	121	8.87
52	80.4	5.45	85.9	5.82	91.1	6.18	103	6.98	114	7.73	134	9.09
54	88.9	5.59	94.9	5.97	101	6.35	114	7.17	126	7.92	148	9.30
56	97.9	5.72	105	6.14	111	6.49	125	7.31	139	8.13	163	9.53
58	107	5.83	115	6.27	122	6.65	138	7.52	152	8.28	179	9.75
60	118	6.01	125	6.37	133	6.77	151	7.69	167	8.50	195	9.93
66	151	6.36	162	6.82	171	7.20	194	8.17	215	9.05	252	10.6
72	191	6.75	203	7.18	216	7.64	244	8.63	270	9.55	317	11.2
78	236	7.11	252	7.59	267	8.05	302	9.10	334	10.1	392	11.8
84	287	7.46	306	7.95	325	8.44	367	9.54	406	10.6	477	12.4
90	344	7.79	368	8.33	390	8.83	441	9.98	488	11.0	.....	.....
96	408	8.12	436	8.67	462	9.19	523	10.4	579	11.5	.....	.....
102	480	8.46	512	9.02	543	9.57	614	10.8	680	12.0	.....	.....
108	558	8.77	596	9.37	632	9.93	715	11.2	.....	.....	.....	.....
114	644	9.09	688	9.71	729	10.3	825	11.6	.....	.....	.....	.....
120	738	9.40	788	10.0	835	10.6	945	12.0	.....	.....	.....	.....

Diameter in Inches	Friction head, in feet, per 1,000 feet length of pipe											
	5.0		6.0		7.0		8.0		9.0		10.0	
	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.
6	0.50	2.55	0.55	2.80	0.60	3.06	0.65	3.26	0.69	3.51	0.73	3.72
8	1.06	3.04	1.17	3.35	1.28	3.67	1.38	3.95	1.47	4.21	1.56	4.47
10	1.92	3.52	2.12	3.89	2.31	4.24	2.49	4.57	2.66	4.88	2.82	5.17
12	3.11	3.96	3.44	4.38	3.75	4.77	4.04	5.14	4.31	5.49	4.57	5.82
14	4.68	4.38	5.18	4.85	5.64	5.28	6.07	5.68	6.48	6.06	6.87	6.43
16	6.66	4.77	7.37	5.28	8.03	5.75	8.65	6.19	9.23	6.61	9.79	7.01
18	9.10	5.15	10.1	5.72	11.0	6.22	11.8	6.68	12.6	7.13	13.4	7.58
20	12.0	5.50	13.3	6.10	14.5	6.65	15.6	7.15	16.7	7.65	17.7	8.11
22	15.5	5.87	17.1	6.48	18.7	7.08	20.1	7.61	21.5	8.14	22.8	8.64
24	19.5	6.21	21.6	6.88	23.5	7.48	25.3	8.05	27.0	8.59	28.7	9.13
26	24.1	6.54	26.7	7.24	29.1	7.89	31.3	8.49	33.4	9.06	35.4	9.60
28	29.4	6.88	32.5	7.60	35.4	8.28	38.1	8.91	40.7	9.52	43.1	10.1
30	35.2	7.17	39.0	7.95	42.5	8.66	45.8	9.33	48.8	9.94	51.8	10.6
32	41.8	7.49	46.3	8.29	50.4	9.02	54.3	9.72	58.0	10.4	61.4	11.0
34	49.1	7.79	54.3	8.61	59.2	9.39	63.8	10.1	68.1	10.8	72.2	11.4
36	57.1	8.08	63.2	8.94	68.9	9.75	74.2	10.5	79.2	11.2	84.0	11.9
38	65.9	8.37	73.0	9.27	79.5	10.1	85.6	10.9	91.4	11.6	96.9	12.3
40	75.6	8.66	83.6	9.58	91.1	10.4	98.1	11.2	105	12.0	.....	.....
42	86.0	8.94	95.1	9.89	104	10.6	112	11.6	119	12.4	.....	.....
48	122	9.71	136	10.8	148	11.8	159	12.6	.....	.....	.....	.....
54	167	10.5	185	11.6	202	12.7	.....	.....	.....	.....	.....	.....
60	221	11.3	245	12.5	.....	.....	.....	.....	.....	.....	.....	.....
66	285	12.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Diameter in Inches	Friction head, in feet, per 1,000 feet length of pipe											
	12.5		15.0		17.5		20.0		25.0		30.0	
	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.
6	0.82	4.18	0.91	4.63	0.99	5.04	1.07	5.45	1.21	6.16	1.34	6.82
8	1.77	5.07	1.95	5.59	2.13	6.10	2.29	6.56	2.59	7.42	2.87	8.22
10	3.19	5.85	3.53	6.47	3.84	7.04	4.14	7.59	4.69	8.60	5.18	9.50
12	5.17	6.58	5.72	7.28	6.23	7.93	6.71	8.54	7.60	9.68	8.40	10.7
14	7.78	7.28	8.61	8.05	9.38	8.77	10.1	9.45	11.4	10.7	12.6	11.8
16	11.1	7.95	12.3	8.81	13.4	9.60	14.4	10.3	16.3	11.7	18.0	12.9
18	15.1	8.55	16.8	9.51	18.2	10.3	19.7	11.1	22.2	12.6	.....	.....
20	20.0	9.17	22.1	10.1	24.1	11.0	26.0	11.9	.....	.....	.....	.....
22	25.8	9.77	28.5	10.8	31.1	11.8	33.4	12.7	.....	.....	.....	.....
24	32.5	10.3	35.9	11.4	39.1	12.4	.....	.....	.....	.....	.....	.....
26	40.1	10.9	44.4	12.0	.....	.....	.....	.....	.....	.....	.....	.....
28	48.8	11.4	54.0	12.6	.....	.....	.....	.....	.....	.....	.....	.....
30	58.6	11.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
32	69.5	12.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

*From Hydraulic and Excavation Tables, Fifth Edition, United States Reclamation Service, Department of the Interior.

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THE AMERICAN WELL WORKS

General Office and Works, Aurora, Ill.
Chicago Office: First National Bank Bldg.

Manufacturers of

"American" Centrifugal and Deep Well Plunger Pumps; Well, Blast Hole and Prospecting Drilling Machines and Tools

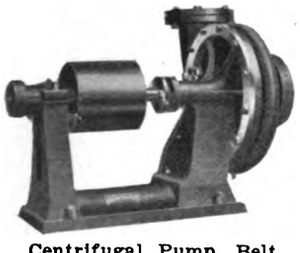
Products

High and low head volute and turbine centrifugal pumps, for every purpose, including mine sinkers, sump pumps; mine station pumps, acid pumps, drainage pumps, water works pumps, power plant pumps, feed water pumps; Deep Well Plunger pumps, single acting, double acting and two stroke; Deep Well Earth and Rock Drilling Machines; Deep Blast Hole Drilling Machines; Rotary Drilling and Coring Machines; complete line of Earth and Rock Tools.

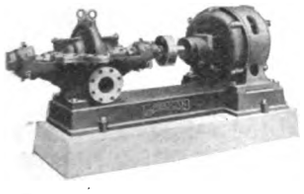
Deep Well Turbine

"American" Centrifugal Pumps

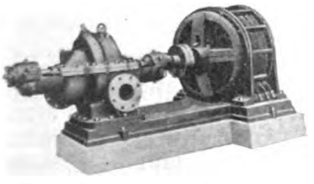
These pumps are made in about twenty standard types, including both horizontal and vertical styles, each in a complete line of sizes, and for any form of drive or with any power. These include both volute and turbine designs to meet the widest possible range of conditions. We design and build special types of pumps to meet unusual conditions, including those for handling gritty water or a large quantity of solid matter and special pumps for handling acids and chemicals. Centrifugal pumps are made in any number of stages required to handle water under any practical pumping lift.



Centrifugal Pump, Belt Drive



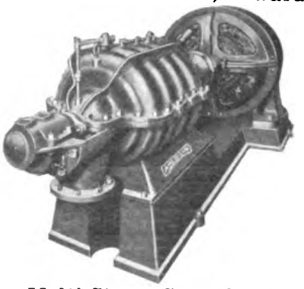
Double Suction Centrifugal Pump



Two-Stage Centrifugal Mining Pump for High Heads

Mine Sinker Pumps

"American" mine shaft sinking centrifugal pumps are made in both single and multiple stage balanced units mounted in steel frames with electric motors and designed to be supported either to the shaft frame or suspended by cable from the surface, permitting them to be readily raised out of the way when blasting and to be lowered as required. These pumps may be mounted in special frames with combination horizontal and vertical motors for operating in inclined shafts.



Multi-Stage Centrifugal Pump

Mine Station Pumps

The great simplicity and compact design of "American" centrifugal pumps, combined with their high efficiency and great reliability, make them particularly suited to every requirement of a mine station pump. They are made in any size and for any head the conditions require. They may be made, on special order, with special bearings for operating in an inclined position.

Power Plant Pumps

"American" power plant pumps are made in any style or capacity, and for any head the conditions require.

"American" Drilling Machines

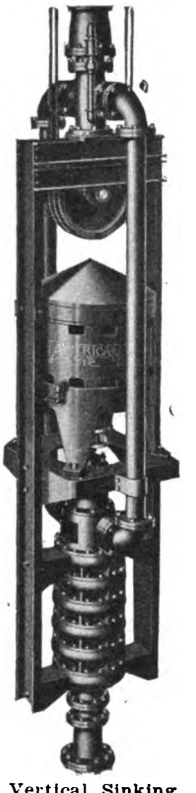
"American" deep well, blast hole, and rotary drilling machines are built in over fifty styles and sizes to meet every requirement of machines for these purposes.

Engineering Department

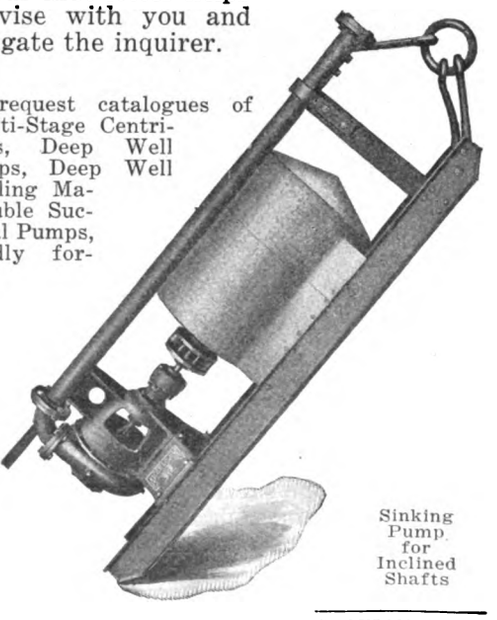
An engineering department with long experience in the mining field is at your disposal. Complete data with your first letter helps them to advise with you and does not obligate the inquirer.

Catalogues

At your request catalogues of Single or Multi-Stage Centrifugal Pumps, Deep Well Plunger Pumps, Deep Well Turbines, Drilling Machines, or Double Suction Centrifugal Pumps, will be gladly forwarded.



Vertical Sinking Pump



Sinking Pump for Inclined Shafts

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Vertical Quintuplex Pump

The pump illustrated in Fig. 117 is suitable for main service stations where it is desired to pump a large quantity of water against a high head. It is

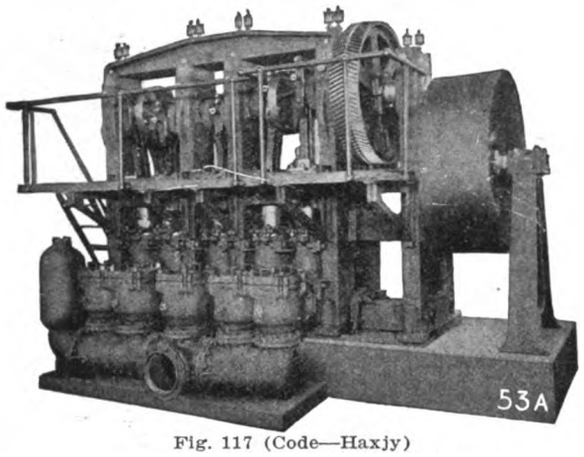

Fig. 117 (Code—Haxjy)

built in capacities ranging from 500 to 4000 gals. per min. against 500 ft. head, to 1800 gals. per min. against 1000 ft. head. Ask for Pump Data 35.

Vertical Triplex Pump "Ydrange" Group

Fig. 185 illustrates one of our "Ydrange" Pumps. These pumps are so designed that each outfit is good for operation against a wide range of lifts, at vari-

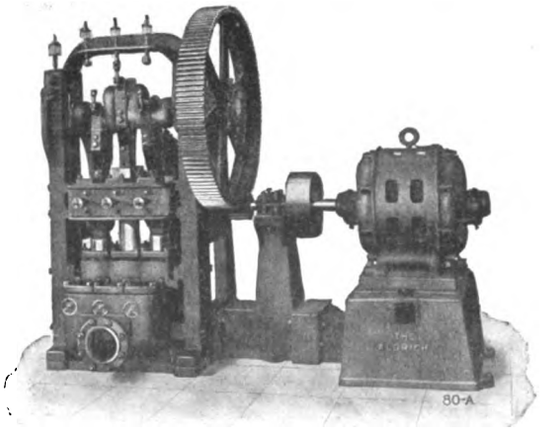

Fig. 185 (Code—Kaxun)

ous capacities, by means of a simple change in plungers or gearing. This type of pump is especially suitable for mine service although also adaptable to general requirements. It is built in sizes ranging from 10 to 500 gals. per min. and suitable for heads up to 2300 feet. Pump Data 60 gives full particulars.

Horizontal Triplex Pump

Fig. 127 illustrates a high speed type of horizontal triplex, operating at about 100 R. P. M. and geared for use with high speed motor. Capacities

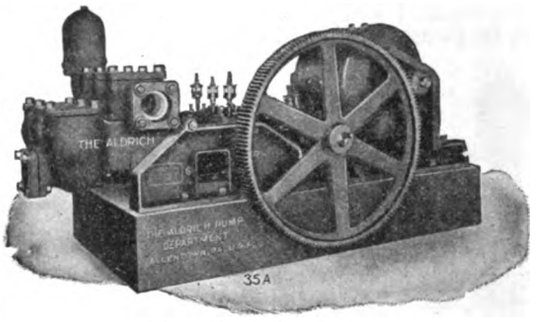

Fig. 127 (Code—Dyjyr)

range from 50 to 250 gals. per min. against heads up to 200 ft.

When the water is acidulous we recommend fitting pumps with our special cement lined water-end, together with bronze lined throats and glands, lead covered or brass cased plungers, or if the water contains considerable grit, with chilled iron plungers.

Pump Data 51 describes this type.

Triplex Sinking Pump

Fig. 118 shows our electric driven direct geared Triplex Sinking Pump for operating in vertical shafts. This pump is equipped with specially de-

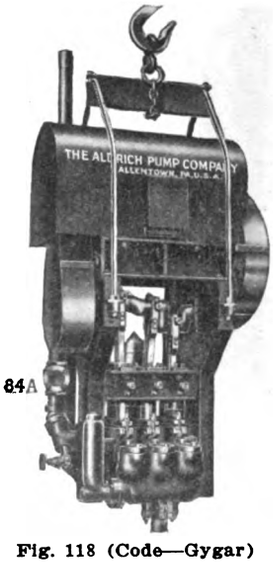

Fig. 118 (Code—Gygar)

signed sling, permitting the raising and lowering of pump, thus giving access to the motor and all working parts. Gears are enclosed in steel casing and motor covered with a steel hood to protect it from drip in the shaft. Capacities 50 to 300 gals. per min. against 350 ft. head. Send for Pump Data 44.

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Divided Water End Vertical Triplex

This type of pump is recommended where a large amount of water is to be pumped against a comparatively low lift. Fig. 170 has herringbone gearing, outboard standard and flexible coupling, making a

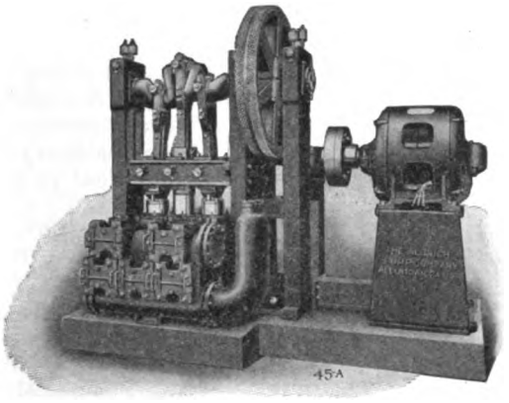

Fig. 170 (Code—Edajk)

very smooth operating and efficient drive and permitting large speed reduction. Capacities are from 350 to 1800 gals. per min. against 100 ft. head, to 350 to 1200 gals. per min. against 350 ft. Pump Data 41 gives full particulars.

Horizontal Quintuplex Pump

The pump illustrated in Fig. 500 is built for deep mine station work and is especially desirable where headroom is low. The mechanical advantage of the quintuplex type of pump is very pronounced on this

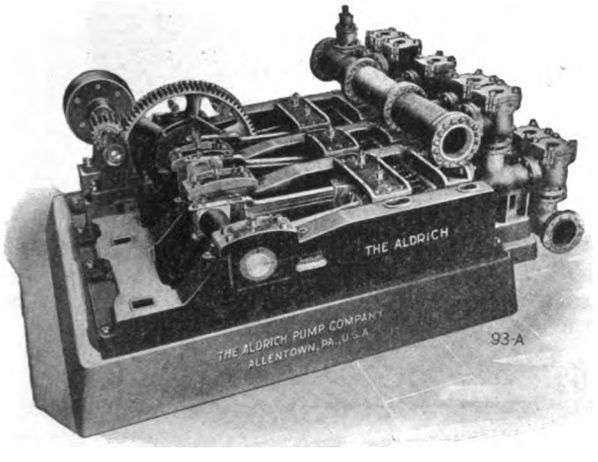

Fig. 500 (Code—Obwea)

service, the strains being distributed throughout the mechanism in a uniform and regular manner, thereby lessening shocks and preventing undue wear. These pumps are built in capacities from 200 to 1500 gals. per min. and to pump against heads up to 2300 ft. Ask for Pump Data 62.

Pot Chamber Type Vertical Triplex

The pumps illustrated in Fig. 164 are built in large capacities and for pumping against lifts up to 1000 ft. The valves are contained in separate and

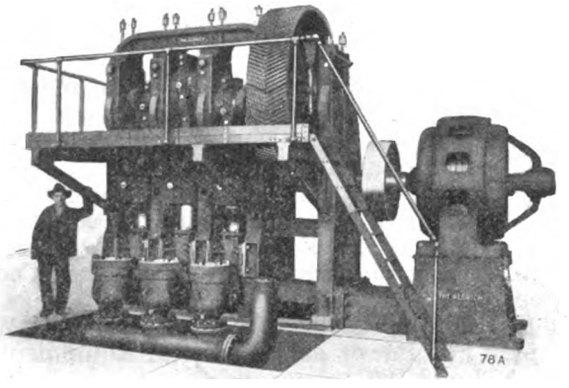

Fig. 164 (Code—Jaabs)

interchangeable chambers and the pumps are very strongly constructed, while all parts are easily accessible.

Send for Pump Data 48.

Portable Triplex Pump

Fig. 155 illustrates one of our Portable Horizontal Triplex Pumps designed especially for pumping out mine sumps and dips. On account of their

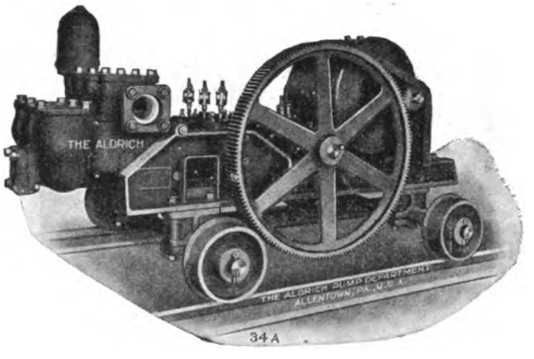

Fig. 155 (Code—Dyjza)

compactness they are particularly suitable for conditions where headroom and floor space are limited.

Being mounted on truck, they can be readily moved from place to place as required.

They are described in Pump Data 51.

Aldrich Pumps are in Operation in Mines Everywhere

Our Engineering Service is at all times at your disposal. Write us giving particulars of your requirements. We will be pleased to give you the benefit of our wide experience in solving mine pumping problems.

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Allis-Chalmers Manufacturing Company

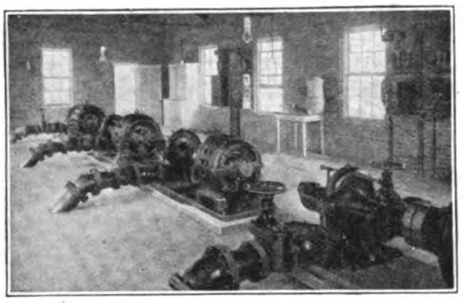
MILWAUKEE, WISCONSIN

For Branch Offices and Other Products, See Page 168

Complete Centrifugal Pumping Units

Products

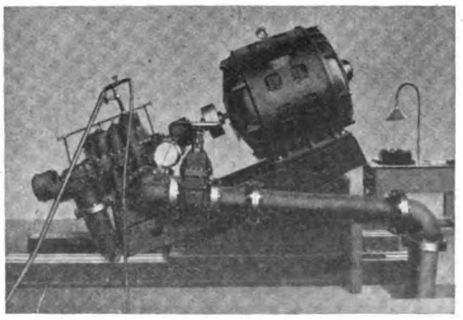
Specialists in the selection, design and manufacture of centrifugal pumps and centrifugal pumping units for most any service, among which as applying to the mining, metal and quarry industry can be enumerated the following: Mine Drainage; Tank Service; Unwatering Service; Mill Water Supply; Fire Pumps; Boiler Feed Pumps; Condenser Pumps; Spray Pumps; Jacket and Cooling Water Pumps; Slimes, Concentrates, Tailings and Sludge Pumps; Hydraulic Sluicing and Wash Pumps. For Power and Electrical Equipment see pages 168 and 169.



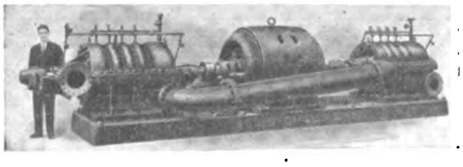
Motor Driven Type S Pumps in Typical Pumping Station

Service

Careful consideration of your pumping problem, the selection of the most suitable pump and drive of our own manufacture (undivided responsibility), the pumps designed for high efficiency, and economically produced ready for quick delivery, a careful shop test before shipment, make up a service which insures the buyer pump satisfaction.



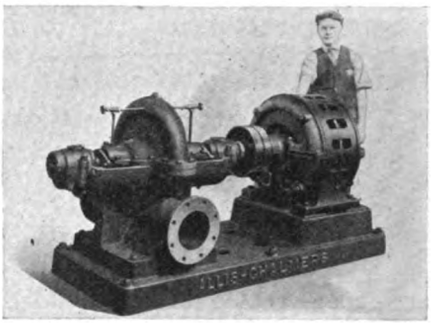
Motor Driven Multistage Mine Sinking Pump on Shop Test



High Lift All Bronze Mine Drainage Pump

Combined Units

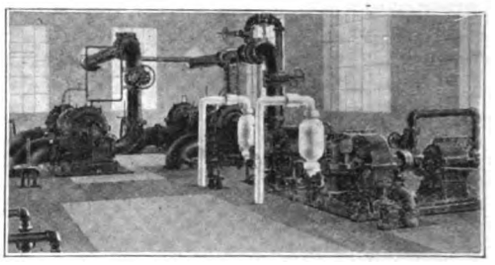
The Allis Chalmers Manufacturing Company make a specialty of combined units consisting of pump and motive power of their own manufacture as the best way to give purchasers a complete unit with both pump and drive properly proportioned. "Complete units of undivided responsibility" have proven the most reliable and economical in service.



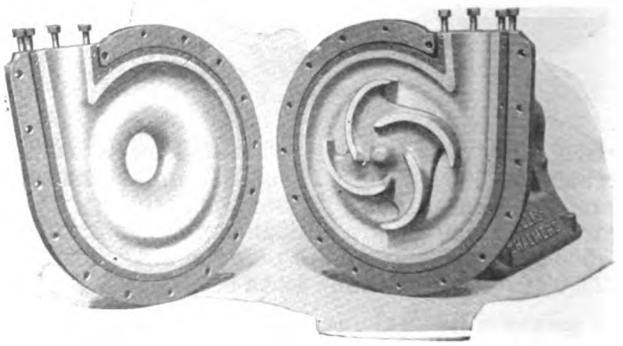
Motor Driven Type S Mill Water Supply Pump

Types of Pumps

The types of pump manufactured as standards are: The Single Stage Type "S", built in sizes from 1½-in. discharge to 24-in. discharge with capacities ranging from 30 g.p.m. to 20,000 g.p.m. and good for heads up to 200 ft. in the larger sizes; the Multi-Stage Type "ST", built in sizes ranging from 2½ to 14-in. and for normal heads up to 500 ft., although we are prepared to build multistage pumps for considerably higher heads.



Allis-Chalmers Pumps in a Power House



Rubber Lined Sand, Slimes, Tailings and Sludge Pumps

Catalogue

When in the market for pumps of any description send for our catalogue.

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AURORA PUMP & MFG. COMPANY

Home Office and Factory: AURORA, ILL.

Chicago Office: 37 West Van Buren St. **New York Office: 152 Chambers St.**

Manufacturers of

Centrifugal and Deep Well Pumps

Products

Centrifugal Pumps for every service; Deep Well Turbine Centrifugal Pumps; Deep Well Plunger Pumps.

Aurora Pumps

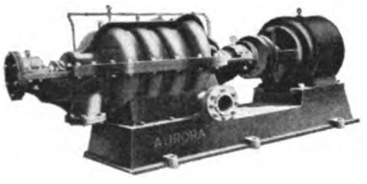
These pumps are the result of more than a quarter-century of practical experience in the designing and building of centrifugal and deep well pumping machinery.

Tests

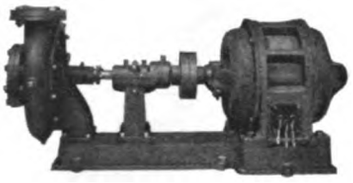
Operating tests and results from present installations prove that Aurora pumps are highly efficient and dependable.

Engineering Service

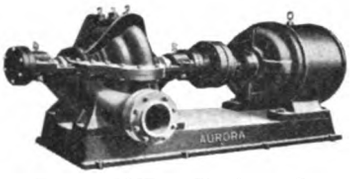
Our engineers are specialists in all hydraulic questions and solicit the privilege of solving your pumping problems.



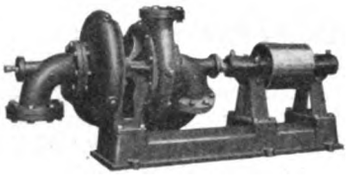
Type PMD, Multi-Stage Horizontally Split Centrifugal Pump.



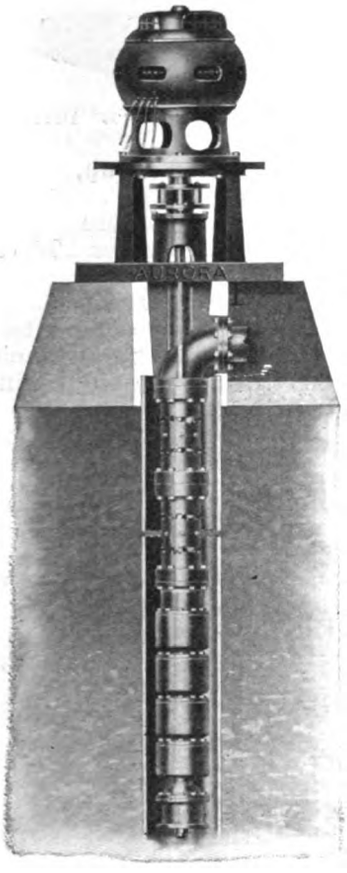
Type GMD, Single-Stage Horizontal High Pressure Motor Driven Centrifugal Pump. Total heads up to 130 ft.



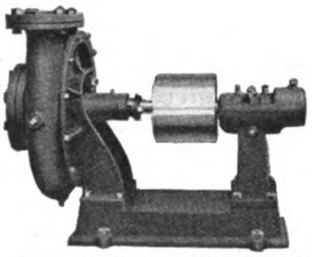
Type OMD, Single - Stage Double Suction Horizontally Split Centrifugal Pump. All sizes.



Type HH, Two-Stage Horizontal High Pressure Centrifugal Pump. Heads up to 250 ft.



Type TMD, Deep Well Turbine Centrifugal Pump. Built for 12-30 in. wells. For belt drive or direct connection.



Type G, Single-Stage Horizontal High Pressure Belt Driven Centrifugal Pump. Total heads up to 130 ft.

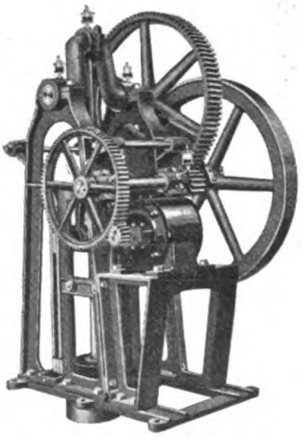


Fig. 100D. Motor Driven Deep Well Power Head. Built for belt or direct motor drive to meet all conditions.

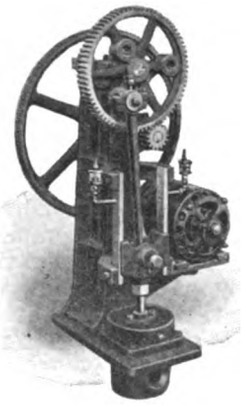
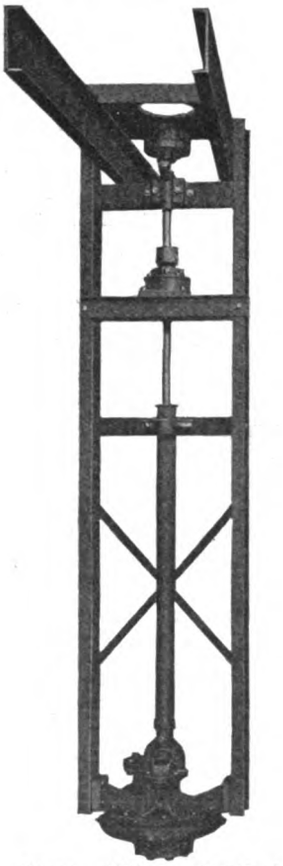


Fig. 150E. Adjustable stroke, 6, 8 and 10 in. Max. H. P. 1½. For installations up to 350-ft. heads; cylinders up to 3¾ in.



Type KIMB, Vertical Single - Stage Centrifugal Pump. Enclosed line shaft, thrust bearing and flexible coupling. Built in all sizes to meet all conditions. Belt or direct motor drive.

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THE DEMING COMPANY

SALEM, OHIO

ESTABLISHED 1880

Deming HAND AND POWER PUMPS FOR ALL USES

General Agencies Specializing on Deming Power Pumps

BOSTON—Chas. J. Jager Co., 13-15 Custom House St.
BUFFALO—Root, Neal & Company, 178-180 Main St.
CHARLESTON, W. VA.—Charleston Electrical Supply Co.
CHARLOTTE—The Deming Co., Realty Building
CHICAGO—Henion & Hubbell
CLEVELAND—Strong, Carlisle & Hammond Co.
COLUMBUS, O.—Scioto Valley Supply Co., Front & Gay Sts.
DENVER—Hendrie & Bolthoff Mfg. & Supply Co.
DETROIT—Kerr Machinery Corporation, Kerr Building
EVANSVILLE—Laib Company
EL PASO—Krakauer Zork Company
FORT WORTH—Atlas Supply Company
KANSAS CITY—English Tool & Supply Co.
NASHVILLE—John Bouchard & Co.
LOS ANGELES—R. W. Sparling Co.
LOUISVILLE—Laib Company
MIAMI—Miami Supply Co., S. W. Second St.
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PHILADELPHIA—W. P. Dallett Co., 922-924 Sansom St.
PITTSBURGH—Harris Pump & Supply Co., 316-322 Second Ave.
PORTLAND—Crane Company
RICHMOND—Sydnor Pump & Well Company
SACRAMENTO—Crane Company
SAN FRANCISCO—Crane Company
SALT LAKE CITY—Salt Lake Hardware Company
TOLEDO—National Supply Company
CANADA: MONTREAL, TORONTO, WINNIPEG, Darling Bros., Ltd.
VANCOUVER—Allan, Morgan & Co.

Products

Hand and Power Pumps for mine and quarry service, and for general water supply, including:

Triplex Power Pumps

which are made in vertical or horizontal types; portable or stationary; single or double acting; electric or belt driven; many different styles and sizes; standard or special construction as conditions may necessitate; capaciies from 5 gallons per minute to 2,000 gallons per minute.

Power Piston Pumps

Electric or belt drive; stationary or portable; standard or special construction, to suit conditions; capacities from 30 to 200 gallons per minute.

Deep Well Working Heads and Cylinders

Electric or belt driven; standard or special construction to suit conditions; for pumping water from deep wells for general water supply.

Information Required For Estimate

It is difficult to make any specific statements concerning the maximum distances which any power pump will lift and force water either vertically or horizontally. This can be accurately determined only when the conditions under which the pump will operate are definitely known.

We, therefore, prefer to treat each installation as a separate case, and suggest that we be supplied with the information requested under the heading, "When Ordering Pumps," as given on Page 440. Upon receipt of this data, our engineers will be enabled to quote on a pump which will suit the conditions.

Guarantee

Our pumps are fully guaranteed to perform the duty for which they are rated or recommended, and we shall hold ourselves under obligation to supply, without charge, any part breaking within one year of date of shipment, where such breakage bears unmistakable evidence of faulty material or workmanship.

For information concerning our complete line of Hand, Windmill, Power and Spray Pumps, write for 256-page General Catalogue No. 26.

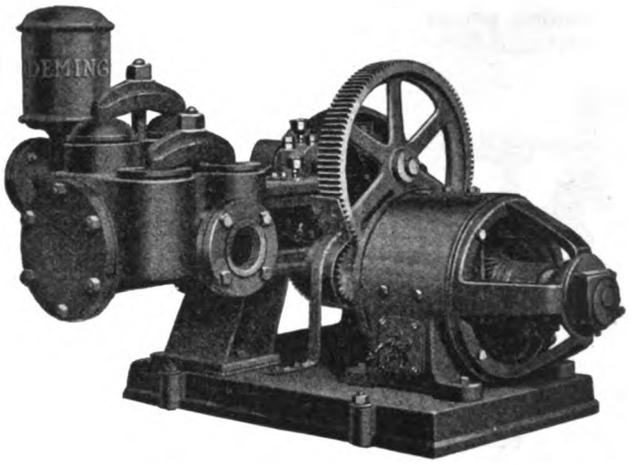

Fig. 696, "Neptune" Electric Pump, with Type "B" Drive.

The "Neptune" Double Acting Piston Pump, Fig. 696

Capacities: 50 to 120 gallons per minute.

Elevations: All three sizes are good for 100 ft. head.

Cylinder: Has heavy anti-acid bronze liner.

Valves: Of the pot valve type. **Loosening two nuts** gives access. Valves are covered by anti-acid bronze plates which protect them from the cylindrically wound springs at the top.

Flanged Pipe Connections and heavy flanged movable air chamber.

Approximate sizes of motor recommended for use with the "Neptune," are given below:

Size Cyl.	Motor	
5x 5	5 H. P.	Based upon a head of 150 feet
6x 6	7½ H. P.	
6x10	7½ H. P.	

Fig. 696, Sizes, Capacities, Etc.

Pistons Diam. Inches	Pistons Stroke Inches	Cap. per Rev., Gals.	Usual Rev. per Min.	Cap. per Min. at Max. Speed, Gals.	Diameter of Pipes Suction Inches	Diameter of Pipes Dischg. Inches
5	5	8.33	50 to 60	49.98	2	2
6	6	1.448	45 to 60	79.64	3	2½
6	10	2.395	40 to 50	119.75	4	3

Gear Ratio 6 to 1.

For information concerning our complete line of Horizontal Piston Pumps, write for Bulletin 310-A.

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Deming TRIPLEX POWER PUMPS AND DEEP WELL WORKING HEADS

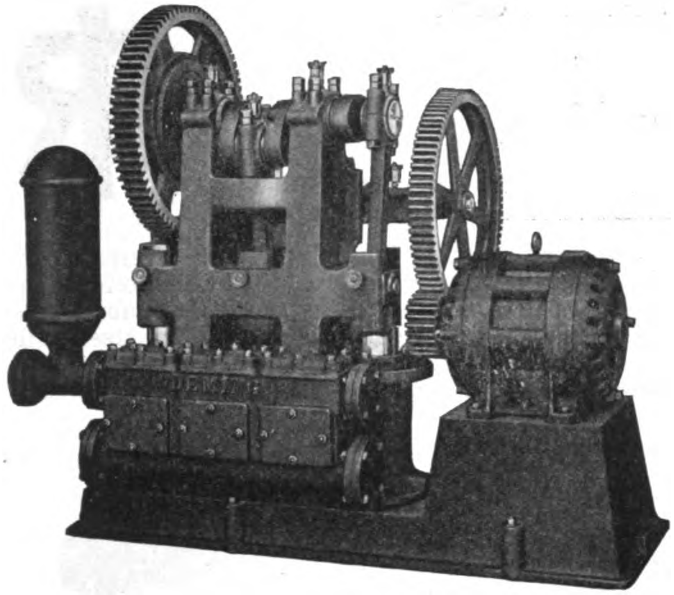

Fig. 50, Size 5½ x 8 with Type "B" Drive.

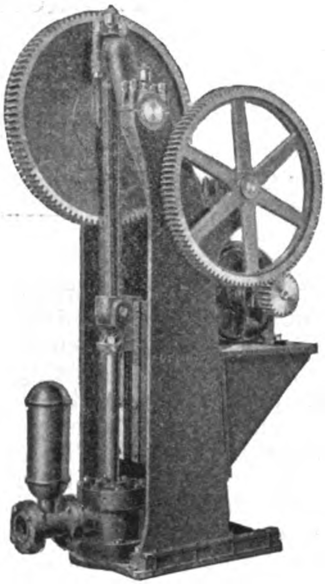

Fig. 80, 24-inch Stroke with Type "B" Drive.

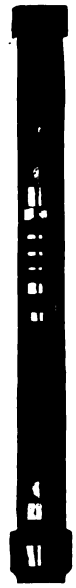

Fig. 324 Cylinder

Fig. 50, Single Acting Triplex Pump. For General Service

One of our most popular vertical triplex power pumps for mine service and general water supply. It is especially adapted for long distance pumping and is good for approximately 300 feet head. We have been manufacturing this particular type with a few modifications for nearly thirty years. Many of the first ones made are still in active service.

Type "B" (Cipher, "TYPEB") includes sub-base on which both pump and motor are mounted, and with gearing connection between pump and motor.

Fig. 50, Standard Sizes, Capacities, Etc.

Plungers		Capacity		Max. Working Pressure, Lbs.	Diam. of Pipes		*Tight and Loose Pulleys	Cipher
Diam. Inches	Stroke Inches	Usual Rev. per Min	Gals. per Min.		Suction Inches	Dischg. Inches		
2	2	70	5.67	150	1½	1	8x 2	Obese
2½	2	70	8.89	150	1½	1	10x 2	Oberlize
2½	3	60	11.4	150	2	1½	12x 3	Oaken
3	3	60	16.2	150	2	1½	14x 3	Oath
3½	3	60	22.	150	2	1½	16x 3	Oakling
3½	4	60	30.	150	2½	2	16x 4	Obelus
4	4	60	39.	150	2½	2	18x 4	Oakum
4	6	60	59.	160	2½	2	20x 5	Oarsman
4½	6	60	74.	150	3	2½	20x 5	Oaky
5	6	60	91.	150	3	2½	24x 5	Oasis
5½	8	60	147.	150	4	3	28x 6	Oatmeal
6	8	55	161.	140	4	3	30x 6	Obduration
7	8	55	220.	150	5	4	30x 8	Obdurate
8	8	55	287.	150	5	4	36x 8	Obiter
8	10	50	326.	140	6	5	36x 8	Overcoat
9	10	50	413.	160	8	6	42x10	Obloquy
10	10	45	459.	150	8	6	42x12	Obsignate
10	12	42	514.	140	8	8	42x14	Objuration
11	12	42	622.	160	10	8	48x14	Obduct
12	12	42	740.	150	10	8	48x16	Obduction
12	14	40	822.	150	12	10	48x18	Observance
13	14	40	965.	140	12	10	48x20	Observant

*Sizes 9x10 and larger regularly furnished with tight pulley only. Gear ratio is 5 to 1.

For information concerning our complete line of Triplex Power Pumps write for Bulletin 300.

Fig. 80, Deep Well Working Head. With Differential Plunger

In this head, the main housing is of such design as to give great strength and rigidity, and also to afford ready accessibility to all working parts. Base plate is extended to permit moving the main housing back for opening the well whenever necessary.

Gearing is machine cut, the main gear being bolted to a large flange integral with crank shaft and located between the main bearings, thereby reducing to a minium, torsional or twisting strains. We recommend that our Fig. 324 brass artesian well cylinder be used in connection with Fig. 80.

Type "B" drive consists of a heavey cast iron shelf bolted to the back of the main housing, on which shelf the electric motor is mounted and connected to the working head by an intermediate gear of rawhide, or other quiet running, pinion. When desired, the motor can be furnished, at extra price.

Fig. 80, Sizes, Etc.

Stroke Inches	Maximum Diameter of Pipes		Gear Ratio	Tight and Loose Pulleys	Height	*Cipher
	Suction Inches	Discharge Inches				
16	9	4	6 to 1	28x6	6'5"	Orient
24	9	4	6.5 to 1	36x6	8'3½"	Oriental

*When telegraphing with reference to type "B" drive, place the cipher word "Typeb" immediately after the cipher word for standard pump.

MAXIMUM SPEED AND CAPACITY PER MINUTE WITH FIG. 324 SINGLE-ACTING CYLINDERS

Diam. of Cyl. Inches	16-Inch Stroke		24-Inch Stroke		†Max. Lift Feet	Max. Depth of Well Feet
	Revs.	Gallons	Revs.	Gallons		
4¼	35	34	28	41	620	540
4¾	35	42	28	51	510	450
5¼	35	52	28	63	410	360
5¾	35	62	28	75	350	300
6¼	35	74	28	89	280	250
6¾	35	86	28	104	240	210
7¾	35	114	28	137	170	150
8½	35	137	28	164	150	130

†From lowest surface of water in well to highest point of delivery. When cylinder is located at a greater depth than 200 feet below the surface, we recommend operating the working head at 20 per cent. slower speed than rated above.

For information concerning our complete line of Deep Well Working Heads and Cylinders write for Bulletin 320-A.

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INGERSOLL-RAND COMPANY

11 BROADWAY, NEW YORK

Manufacturers of

Pumping Machinery

For Offices and Products See Pages 170, 171, 172, 298, 299 and 300

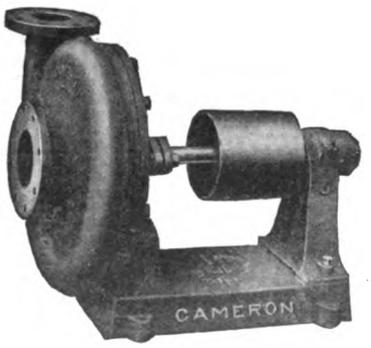
Products

The A. S. Cameron Steam Pump Works manufacture a complete line of centrifugal and direct-acting steam pumps. The centrifugal line includes single-stage, single-suction, volute pumps; single-stage, double-suction, volute pumps (horizontal and vertical) (with either the enclosed or open type of impeller); multi-stage turbine pumps. These pumps are furnished either direct-connected through flexible coupling to electric motor, steam turbine, oil, gasoline or gas engine, or for belt, rope or water turbine drive. The Cameron line also includes Deep Well Pumps; Fire Pumps; Power Pumps.

The line of Cameron Direct-Acting Reciprocating Steam Pumps includes both the piston and plunger types and vertical plunger sinking pump any of which may be operated by steam or compressed air.

Cameron Centrifugal Single Suction Volute Pumps Class "SV"

To meet the wide spread demand for a thoroughly well made and efficient centrifugal pump that can be purchased at a moderate price we have developed this single-suction open impeller pump.



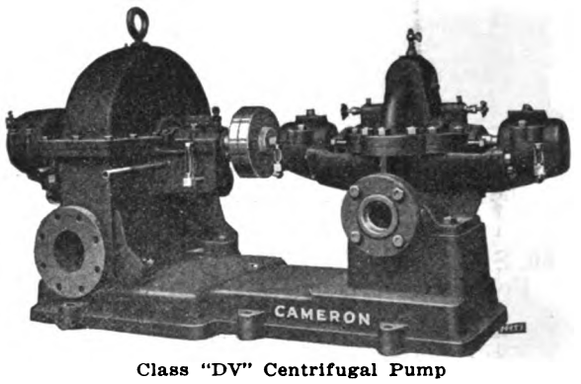
Class "SV" Centrifugal Pump

These pumps are furnished for belting to steam engine, gas engine or some other form of prime mover.

While not high priced they are carefully designed in every respect; of generous proportions and of the best materials. The usual Cameron guarantee accompanies each one. They are offered in sizes up to 12″ for various capacities, and for heads up to 70′. The belt driven pumps, of all sizes, will be carried in stock so that quick deliveries can be made. Bulletin No. 7252.

DATA ON CLASS "SV" SINGLE-SUCTION VOLUTE PUMPS

Size	Diameter Discharge	Diameter Suction	G.P.M. Heads up to 70 ft.	B.H.P.
1	1	1½	45- 90	1.38 - 5.90
1½	1½	2	75- 180	2.37 - 9.10
2	2	2½	126- 300	3.27 - 13.3
2½	2½	3	160- 330	3.85 - 13.0
3	3	4	250- 550	5.61 - 20.7
4	4	5	430- 920	7.13 - 28.0
5	5	6	600-1500	10.6 - 45.0
6	6	8	955-1905	17.6 - 56.1
8	8	10	1500-3100	24.8 - 91.5
10	10	12	1800-4000	32.01-111.0
12	12	15	3200-6200	49.7 -189.0



Class "DV" Centrifugal Pump

Cameron Centrifugal Double-Suction Volute Pumps Class "DV"

The Class "DV" is a double-suction impeller pump suitable for low or moderate heads. Built in single units for heads up to 230 ft. or arranged in series these pumps are satisfactory for heads as high as 460 ft. Casing and bearings are horizontally split to facilitate inspection. Bearings are self-aligning. For low heads or pressures the double-suction feature eliminates the necessity for thrust bearings. For higher heads or pressures, the Kingsbury thrust bearing is furnished. Double wearing rings, between impeller hub and shaft are replaced from stock and no machining is needed. Bulletin 7350 and 7055.

DATA ON CLASS "DV" DOUBLE-SUCTION VOLUTE PUMPS

Size No.	Diam. Discharge Inches	Diam. Suction Inches	G.P.M. 15′ Total Suction Lift	Floor Space Including Motor		
				Length	Width	Height
2	2	2½	125	50	16	18
2½	2½	3	200	52	18	19
3	3	4	300	56	20	21
4	4	5	450	61	22	22
5	5	6	650	73	26	27
6	6	8	1000	81	29	29
8	8	8	1400	84	31	33
10	10	10	2400	101	35	38
12	12	12	4000	117	40	44
14	14	14	6000	130	40	49
16	16	16	8000	136	49	54
18	18	18	10500	143	54	60
20	20	20	14000	154	63	69
24	24	26	20000	190	72	84

Cameron Centrifugal Multi-Stage Turbine Pumps, Class "MT"

The Class "MT" is a single-suction impeller pump for high pressures or heads. This type is available up to five stages in a single casing. Where more than five stages are required, the casings are arranged in series.

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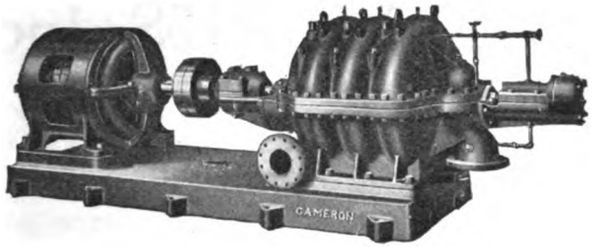
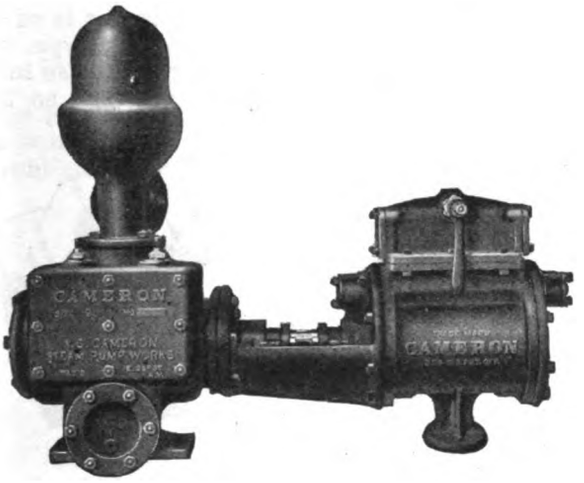


Class "MT" Centrifugal Pump

Standard double wearing rings between impeller hubs and shaft keep joints tight and can be replaced from stock without machining. Horizontally split casing and bearings facilitate inspection. Bearings are self-aligning. Either Kingsbury thrust bearing or hydraulic balancing device is furnished. Bulletin 7351.



Type "GSS" Single Direct-Acting Pump

Cameron Single Direct-Acting Pumps

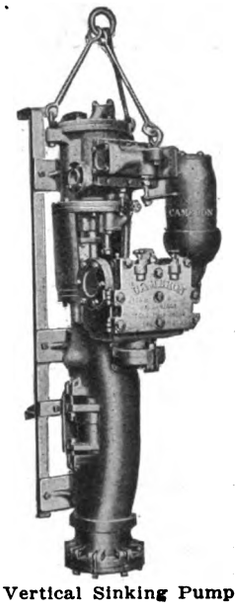
This type has fewer working parts than any other steam pump made. Only four parts go to make up the entire steam mechanism. This type has no dead centre and will always start at any point of the stroke. This pump can be completely taken apart without disconnecting any of the piping. Water piston, water cylinder, bushings and long body piece are furnished of bronze or iron. This pump is also furnished with removable bushing. Bulletin 7304.

DATA ON DIRECT-ACTING STEAM PUMPS, TYPE "GSS"

Diameter of Steam Cylinder, Inches	Diameter of Water Cylinder, Inches	Stroke of Piston, Inches	Ratings: On General Service (Must be Reduced 20% if Suct'n Lift is High) Gals. per Min.	Piston Speed	Ratings: On Boiler Feed Service. (Basis 34.5 lbs. Water Evaporated per Boiler H.P.) Horse Power	Piston Speed	Steam Pipe, Inches	Exhaust Pipe, Inches	Suction Pipe, Inches	Discharge Pipe, Inches	Floor Space
4	2	6	12	75	90	38	⅜	½	1¼	1	40"x10"
5	2½	6	19	75	140	38	½	¾	1½	1¼	40"x10"
6	4	7	49	75	359	38	¾	1	2½	2	47"x14"
7	4	7	49	75	359	38	¾	1	2½	2	47"x15"
6	4	12	81	125	580	63	¾	1	3	2½	4'10"x17"
8	4	12	81	125	580	63	1	1½	3	2½	4'10"x18"
7	5	13	130	128	942	64	1	1½	4	3	5'3"x20"
10	5	13	130	128	942	64	1¼	2	4	3	5'5"x23½"
10	7	13	206	103	1500	52	1¼	2	5	4	5'5"x23½"
12	7	13	206	103	1500	52	1½	2½	5	4	5'6"x24"
14	9	18	248	75	1817	38	2	3	6	5	6'9"x30"
14	10	18	408	100	2956	50	2	3	8	6	7'6"x30
16	10	18	408	100	2956	50	2½	4	8	6	7'6"x37"
16	12	20	510	87	3743	44	2½	4	10	8	8'5"x41"
18	12	20	510	87	3743	44	3	4	10	8	8'5"x41"

Cameron Vertical Plunger Sinking Pumps

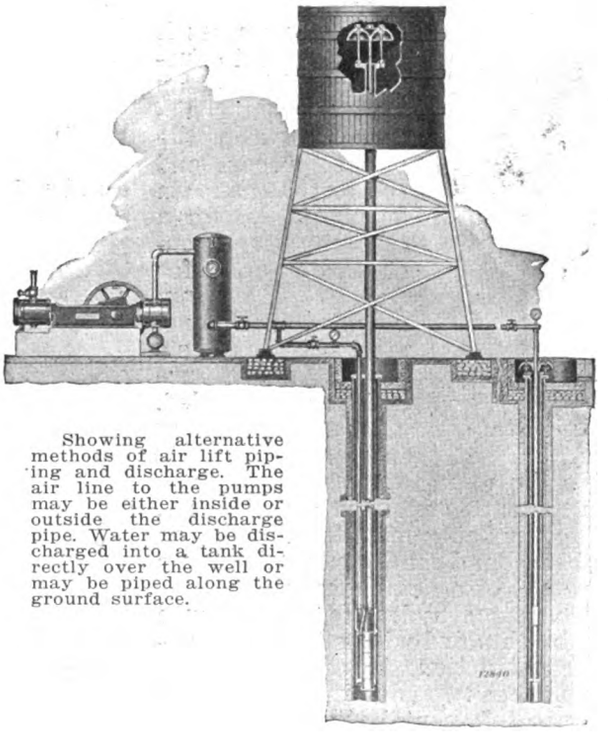
The Cameron Vertical Sinking Pump retains all the advantages of the horizontal types. It has no exposed parts liable to breakage; it takes up less room in the shaft than any other type of pump; it can not be damaged by collision with side walls; and it is designed and intended to handle gritty water. Bulletin No. 7304.



Vertical Sinking Pump

Air Lift Pumping Systems

The Ingersoll-Rand Company has installed Air Lift Systems since the inception of air lift as a commercial method of pumping. Ingersoll-Rand Air Lift equipment of today is the result of long experience and extensive experiments conducted at our plant.



Showing alternative methods of air lift piping and discharge. The air line to the pumps may be either inside or outside the discharge pipe. Water may be discharged into a tank directly over the well or may be piped along the ground surface.

The Air Lift is simple and at all times reliable. There are no moving parts in the well and, therefore, nothing to get out of order. Ingersoll-Rand Compressors, installed in any convenient and central location, are all the working machinery. Any number of wells may be pumped from one central station. Bulletin 77.

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BYRON JACKSON IRON WORKS, Inc.

Wherever Water is to be Lifted

SHARON BUILDING, SAN FRANCISCO

LOS ANGELES VISALIA SALT LAKE CITY

PORTLAND, OREGON

Centrifugal and Turbine Pumps

Products

Centrifugal and Deep Well Turbine Pumps.

Uses

The Byron Jackson Iron Works has made a specialty of the development of centrifugal pumping equipment to meet the demand of the mining industry for maximum efficiency and continuous operation with a minimum of attention.

Mining pumps fall naturally into several classes, each of which has its special application.

Unwatering Pumps—Vertical Shaft

Figure No. 1 illustrates the simplest construction of a vertical unwatering pump, the requisite number of stages for any head or capacity being supplied. In this construction the pump proper and motor are mounted on a cast iron barrel.

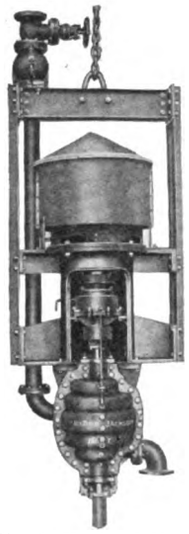


Fig. 1. Vertical Unwatering Pump—Short Motor Barrel Construction

In some cases it is advisable to furnish a sinking pump with a greater distance between the pump proper and the motor than can be obtained with a cast iron barrel construction and for such work a pump mounted in channel steel frame, as shown in Figure 2 is recommended. The usual practice in this design is to space the pump proper and the cast iron motor barrel twenty feet apart, the motor being mounted directly on the barrel and connected to the pump by means of a flexible coupling.

Fig. 2. Vertical Unwatering Pump in Channel Steel Frame

The same hydraulic performance may be obtained with either mechanical construction, the difference between the two designs being the distance between the pump and the motor. The channel steel frame should be adopted when there is a considerable flow of water and possible intermittent power service, as the motor is safeguarded against damage from water rising in the shaft.

Incline Shaft

For incline work a unit such as is shown in Figure 3 is furnished, this being a pump with grease bearings throughout and with a heavy thrust bearing mounted between the motor and the pump. A solid coupling is used to connect the motor to the pump shaft.

The thrust bearing carries not only the hydraulic thrust on the pump itself but also the down thrust from the rotor of the motor. The motor is of the ball-bearing type, permitting of grease lubrication, so that the pump may be operated at any angle, from horizontal to vertical.

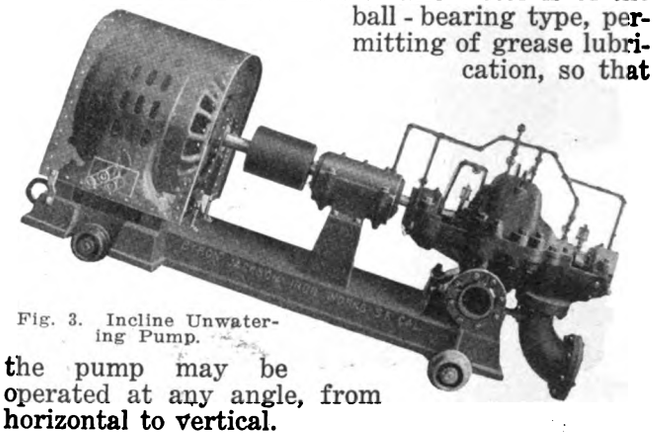
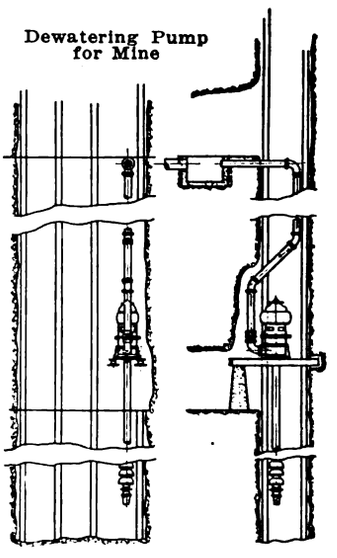


Fig. 3. Incline Unwatering Pump.

Deepwell Turbine—Vertical Shaft

The use of deepwell turbines for unwatering mine shafts is of recent development. This pump consists of a series of stages located at the bottom of the mine shaft and suspended from the surface. The runners are operated by a vertical line shaft carried through an enclosed tubing, in which the bearings are located, this tubing acting as a protection for the shaft and bearings, as well as an oil conduit.



Dewatering Pump for Mine

Fig. 4.

Surrounding and concentric with the driving shaft and its enclosed tube is the discharge pipe suspended from the head. This pipe carries the weight of the pump. The rotating element of the pump is supported by a thrust bearing located in a water-cooled chamber in the discharge head at the surface.

As the discharge column is more expensive than pipe, the best engineering practice calls for the placing of the discharge head with vertical motor at a station located above high water in the mine, and the carrying of

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discharge pipe to the surface. The pump itself is furnished with sufficient stages to pump from low water to the surface of the ground, without reference to the actual length of the pump column.

Where no electric power is available it is necessary to bring the discharge and drive shaft to the surface of the ground and operate belted with gas engine, or other power.

The advantage of this style of pump for unwatering work is obvious. The pump can be installed with its motor set permanently above high water in the mine. On completion of installation the pump is turned on and will then operate continuously without further resetting until the unwatering has been accomplished. This means a considerable saving in field labor as it eliminates the stopping of unwatering operations to permit the raising or lowering of the pump.

Station Pumps

The Byron Jackson Iron Works is manufacturing a volute multi-stage pump for station service, sectional elevation of which appears in Fig. 6.

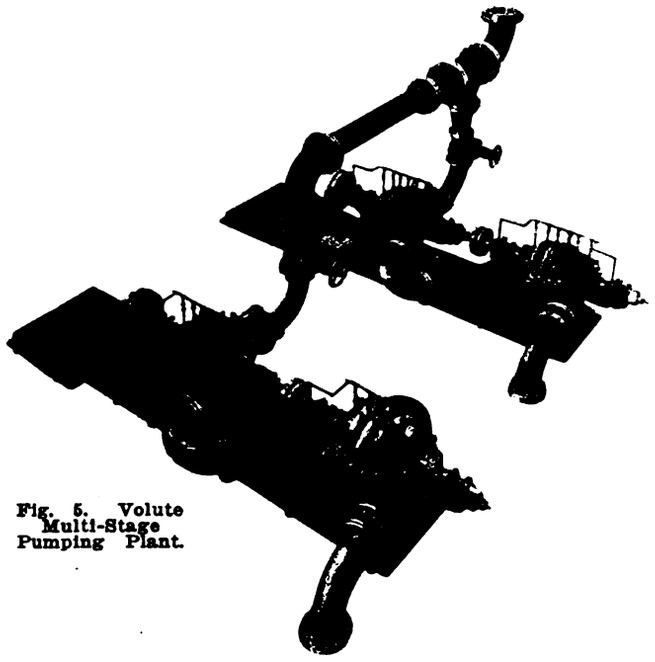

Fig. 5. Volute Multi-Stage Pumping Plant.

In the construction of this pump the velocity of the water from each runner is converted to pressure before entering the next runner by means of volute passages; the diffusion vane of the turbine pump being eliminated. In handling gritty mine water experience has shown that the first part of the pump to evidence wear is the diffusion vane, on which the gritty water is delivered at high velocty. With the wear on the tip of the vane and the consequent change in the angle of diffusion, the pump efficiency, and the quantity of water handled, falls off very rapidly. This is the main difference hydraulically between the volute multi-stage pump and the older turbine patterns.

Mechanically the pump is designed with runners back to back to eliminate all end thrust. As an additional precaution a water-cooled thrust bearing is provided, but this bearing has practically no load to carry.

The back to back construction is also of great practical value in that the pressure on the packing gland on the discharge side of the pump is reduced to half the actual working head, instead of the entire working head, as would be the case if the runners were to face in the same direction. Operators familiar with packing gland difficulties on 1500′ and 2000′ pumps will appreciate the practical value of this design. This pump is built in multiples of two stages. High head units may necessitate the compounding of two or more pumps.

The usual split case type of construction is followed, thus permitting of inspection or removal of rotating element without disturbing the piping. The pumps are built with external, ring oiling bearings, of liberal dimensions with bronze runners of the enclosed type, mounted on heavy steel shaft, bronze covered at all points coming in contact with the liquid.

Rubber Lined Pumps

After months of experiment and study, the Byron Jackson Iron Works has developed a design

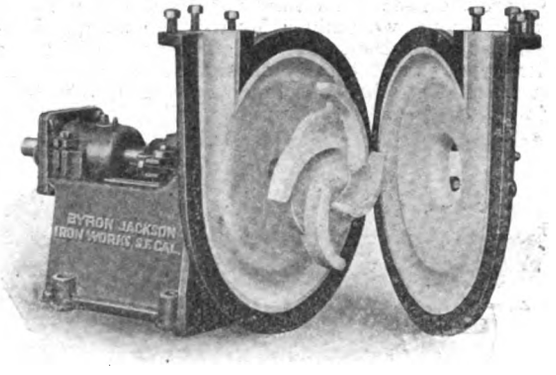

Fig. 7. Rubber Lined Slime Pump, Exposed View.

of rubber lined pump, whose wearing parts will have a maximum life when handling abrasive substances.

This pump is adapted to the handling of mill slimes or other material of 15 mesh and finer; many chemical solutions which ordinarily attack iron, bronze and other metals, but which have no action on rubber; chemical solutions containing more or less grit. These are efficiently elevated with this rubber lined pump.

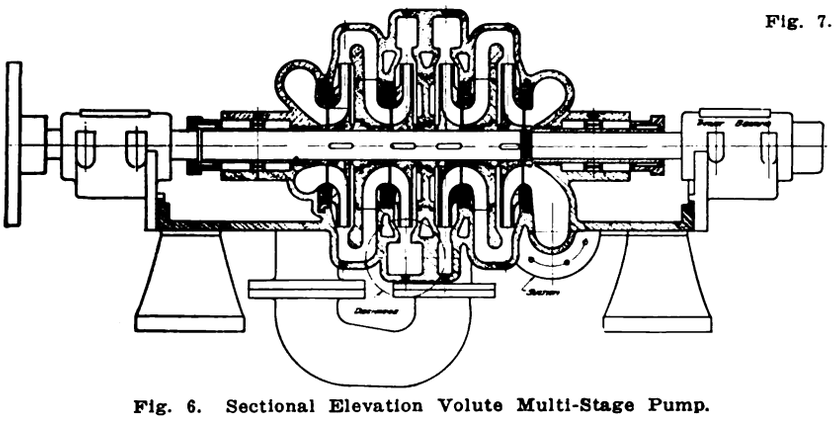

Fig. 6. Sectional Elevation Volute Multi-Stage Pump.

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MORRIS MACHINE WORKS

BALDWINSVILLE, NEW YORK

PHILADELPHIA—Real Estate Trust Bldg.
PITTSBURGH—Harris Pump & Supply Co.
DETROIT—Penobscott Building
NEW YORK—39-41 Cortlandt St.
CHICAGO—Henion & Hubbell, 217 N. Jefferson St.
CHARLOTTE, N. C—Realty Bldg.

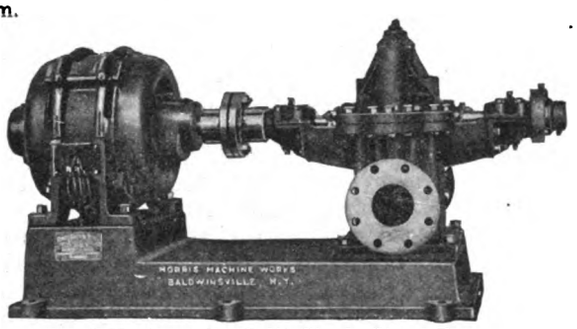
REPRESENTATIVES IN PRINCIPAL CITIES

Products

Centrifugal Pumping Machinery; Hydraulic Dredges; Stationary and Marine Engines.

Horizontally Split Single-Stage Pumps

This type of pump is especially adapted for high efficiency and for operating at high speed for direct connection to electric motor or turbine. It is also built for belt drive. Suction and discharge openings are in the bottom half of shell, therefore, top can be removed without disconnecting them.



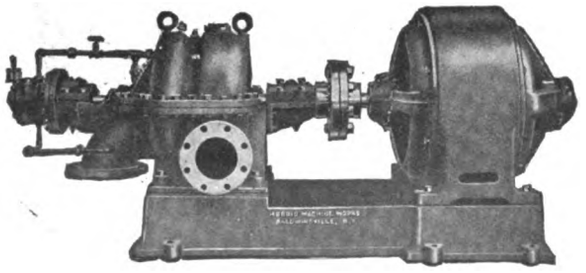
4" Horizontally Split Single-Stage Pump

The enclosed impellers are of bronze, accurately finished and balanced for high speeds. The shaft is of steel, protected by bronze sleeves through the stuffing boxes. The Single-Stage pump is of the double suction type and whatever slight thrust develops is compensated by ball bearings.

Built in sizes ranging from 2 to 20 inches, and for operating in acidulous water can be furnished of acid resisting bronze.

Horizontally Split Multi-Stage Pumps

Where the head is too high for the double suction pump described above, we build a Multi-Stage pump. This type is designed along the same lines as the Single-Stage double suction type, except that being side suction, it develops an end thrust. This thrust is taken care of by a water-cooled marine type bearing running in oil. Leakage between stages is prevented by bronze labyrinth rings.



6"—2 Stage Horizontally Split Multi-Stage Pump

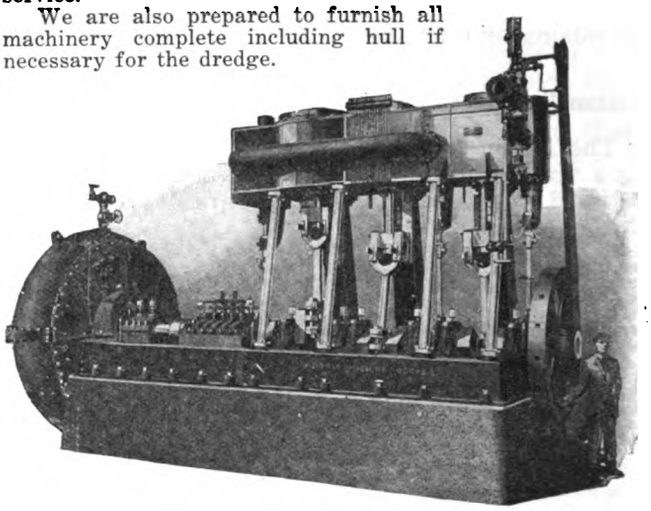
Built in sizes ranging from 2 to 14 inches, the number of stages depending upon the head. Also built of acid resisting bronze for operating in acidulous water.

Hydraulic Dredging Pump

The merits of the hydraulic suction dredge are well recognized and in comparison with other systems of dredging it has been proved to be the most economical for handling sand, gravel, mud, clay, etc., or in fact any material except solid rock. The hydraulic dredge consists mainly of a centrifugal dredging pump with power to drive same and auxiliary machinery for handling suction pipe and boat. The pump in operation creates a strong suction flow in the suction pipe sufficient to pick up the material and draw it into the pump from which it is again delivered through the discharge line any distance to point of delivery, and can at the same time be elevated to reasonable height.

We build our pumps either to be operated by belt or directly connected to engine, simple, compound or triple expansion. We have for all sizes of dredging pumps many different patterns and can furnish these pumps for any service.

We are also prepared to furnish all machinery complete including hull if necessary for the dredge.

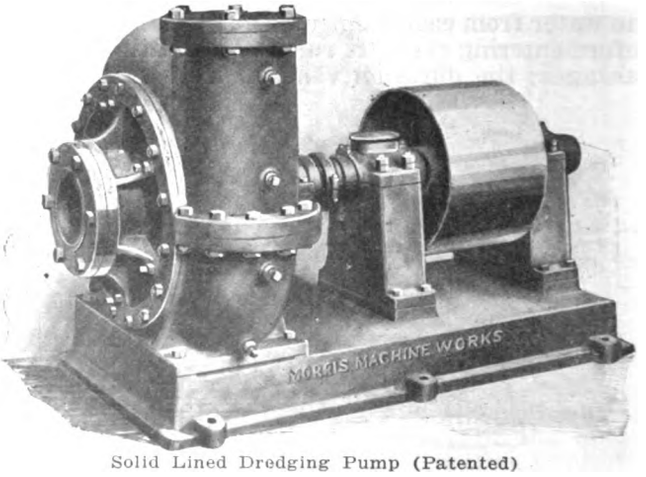


20" Dredging Pump Directly Connected to 1000 H. P. Triple Expansion Engine

Solid Lined Dredging Pump (Patented)

This type of pump was first designed for handling tailings and slimes in connection with gold recovery plants, and it was the first pump on the market suitable for that exacting service. For over 30 years we maintained an office in Johannesburg and thousands of Morris pumps are operating in the Transvaal gold fields. This pump is also extensively used for ordinary dredging, as the inner lining is made either of manganese steel or hard iron. The piston is also made of the same material as the lining. Owing to its construction and extremely heavy proportions it is comparatively expensive as regards first cost but when compared with its lasting qualities it will be found to be economical in operation.

Built in sizes ranging from 2" to 12" inclusive.



Solid Lined Dredging Pump (Patented)

Since the Civil War, Builders of Centrifugal Pumps, Hydraulic Dredges and Steam Engines

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Worthington Pump and Machinery Corporation

Executive Offices
115 Broadway, NEW YORK

For List of Works and Offices, See Page 493

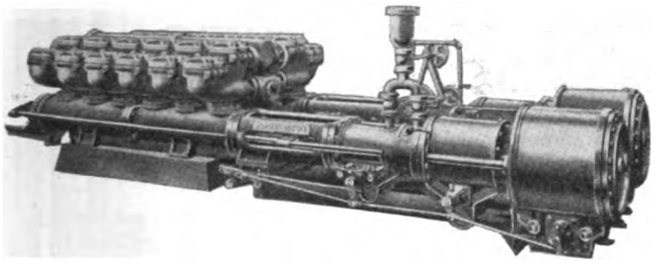
MINE PUMPS

Products

Mine Pumps. For other products see Pages 165, 166, 167, 176, 493, 626 and 741.

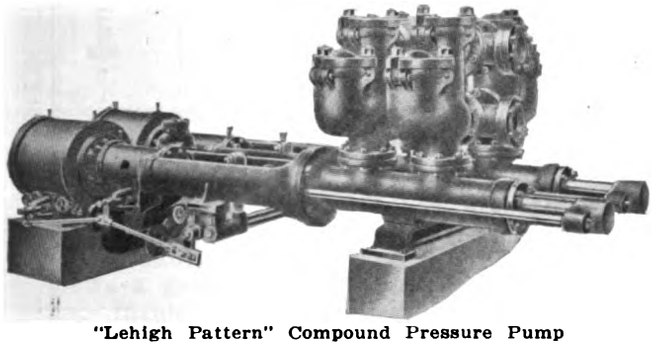
Worthington Mine Pressure Pumping Engines, "Lehigh" Pattern

This pump is intended for deep mine service. The water end differs from the ordinary pressure pump in that the valve pot castings are larger and fewer of them are used for a given capacity, and the valves themselves are larger, giving the fewest possible number of pieces to be handled when making repairs, or when the water end is opened for inspection. Valve area is unusually great, allowing ample margin to speed up engine to handle any sudden excess of water in emergency.



"Lehigh Pattern" Triple Expansion Pressure Pumping Engine

These pumps are made in capacities from 220 to 1,040 gallons per minute, for heads from 400 to 1,000 pounds pressure.



"Lehigh Pattern" Compound Pressure Pump

Vertical and Special Pumps

Where conditions require it, we can furnish a Vertical or Special pump, for installations where floor space is limited. Worthington has many patterns, and from one of these a pump suitable to the particular conditions can be selected.

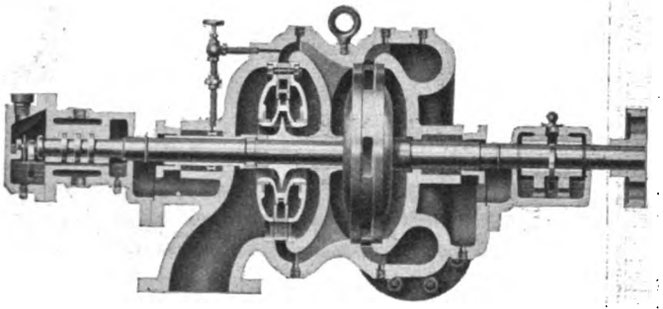
Worthington Outside Packed Plunger Pumps

This line includes pumps for all general service conditions. The Scranton Pattern is a representative pump of this line. It is designed for rough and heavy service, for which ordinary piston pattern pumps are not suitable. For use where water contains sand and grit, where pressures are over 140 pounds per square inch. Ready accessibility to all moving parts is a feature of this pump.

Double Suction Turbine Pumps

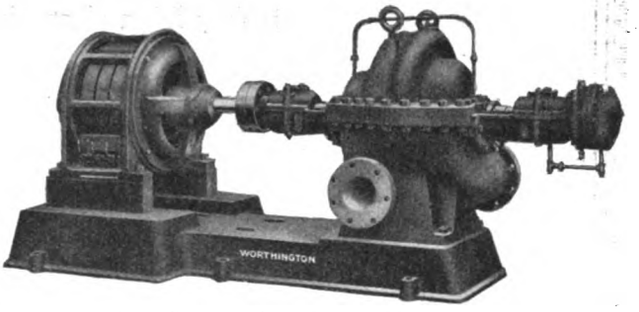
These pumps are built in 1, 2 and 3 stages and deliver against a head of 220 feet per stage, or in a 4-stage pump will work against about 900 feet head.

For greater service two pumps are connected in series.



Sectional View of Double Suction Turbine Pump

The two-stage volute pump is well suited for handling muddy or gritty water and, therefore, is frequently used in mine service. Built from 4 to 8-inch discharge and arranged for connection to motor or steam turbine.



Two-Stage Volute Pump, Motor Drive

These pumps have a wide range of application, including: Water Works, Station Pumps and Sinking Pumps for Mine Drainage; Hydraulic Mining; Boiler Feed Service; Fire Pumps, etc.

Hydraulic Mining

Worthington pumps for this service are more often arranged for direct connected motor drive, but those of the belted type can also be used to advantage. It is common practice to arrange the pumps in pairs, piped up so that they can be used either in parallel or series. This makes it possible to double the pressure by operating in series when a hard stratum is encountered. For moving softer material, the pumps are operated in parallel, and by doubling the capacity it increases in proportion the amount of material removed.

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SECTION X

Ventilation

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

American Blower Company
Bemis Bro. Bag Co.
Buckeye Blower Company
Du Pont, E. I. de Nemours & Company, Inc.
Jeffrey Manufacturing Co., The

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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VENTILATION DATA

THE WEIGHT OF AIR

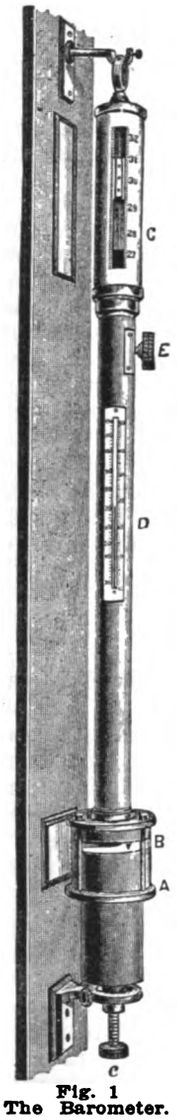

Fig. 1
The Barometer.

Living as we are at the bottom of an atmospheric ocean, estimated to be about 45 miles deep, we have long since come to accept the truth of the statement that air has weight. If proof were wanted we could find it in every gentle breeze which blows, or in the wind blast, raging with a violence that levels buildings and scatters ruin in its path. Both of these phenomena are due to a difference in the weight of air bodies. It is likewise a matter of every-day observation that warm air rises while the cooler air falls. To this fact is due the burning of a lamp, the heated air rising above the wick and drawing in a continual supply of cooler air from below. The explanation of this is that the air above the flame, being heated, expands and becomes lighter in weight, volume for volume, than the surrounding cool air which rushes into the lamp in an endeavor to restore equilibrium. Another familiar way of demonstrating that air has weight, and therefore pressure, is by its action in forcing water through a suction pipe into a pump chamber from which the air has previously been exhausted.

Air, therefore, though comparatively light, is positively heavy, having a weight of its own. A square inch of it measured from the surface of the earth at sea level to the top of the atmosphere, is no less than 14.7 pounds in weight. The instrument used to record the weight, or pressure of the atmosphere, is known as the barometer, and is shown in Fig. 1. This consists of a glass tube about 34 inches long, filled with mercury and inverted with its lower end constantly below the surface of mercury in a cistern. The pressure of the air having access to the mercury in the cistern raises the mercury in the tube to a point where a balance between the two obtains. By means of a scale, C, graduated in inches, the height of the mercury column is read, which thereby indicates the pressure of the air. In reading the barometer the surface of the mercury in the cistern must be brought to the fixed zero. This is done by turning the screw, c, until the mercury just touches the point of a pin projecting downward from the frame of the instrument, which point is the zero of the scale.

The average height of the mercury column at sea level is 29.925 and if it have a cross section of one square inch its weight will be 14.696 pounds. Since there is perfect equilibrium between the mercury column and the atmospheric column it follows that the weight of the mercury, 14.696 pounds, is the measure of air pressure on one square inch of surface. For ordinary computations the height of the mercury at sea level may be taken as 30 inches and its weight 14.7 pounds. Since the pressure of air is due to its weight, points of high elevation will show a lower barometer reading than 30 inches, while points below sea level will show a higher reading.

The weight of dry air, being dependent upon altitude and temperature, may be determined at any altitude and temperature by means of the following formula:

$$w = \frac{1.3273 \times B}{460 + t} \qquad (a)$$

where w = the weight of one cubic foot of air
B = the barometer reading in inches of mercury
t = the temperature of the air in Fahrenheit degrees.

NATURAL MINE VENTILATION

The temperature at any point on the earth's surface fluctuates considerably throughout the day and shows a greater variation with the seasonal changes. Inside the mine, however, conditions are such as tend to hold the temperature fairly constant day in and out, throughout the year, the variation at places well within not much exceeding five degrees. In the winter period the temperature of the incoming air is raised by rubbing against the top and sides, by the burning of lamps, breathing of men and animals, oxidation of sulphides and wood, natural heat of the strata, etc., all of which add their quota of heat to the cold air. In the summer time, the strata being colder than the incoming air, the latter is chilled and rapidly cooled until approximately the same temperature is reached as prevailed in the winter period.

Assuming the inside temperature to be 60 deg. F. (which is probably quite close to the average the year around in the Eastern states) and an outside temperature of, say, either 20 deg. F. or 90 deg. F., it follows that owing to this difference in tempera-

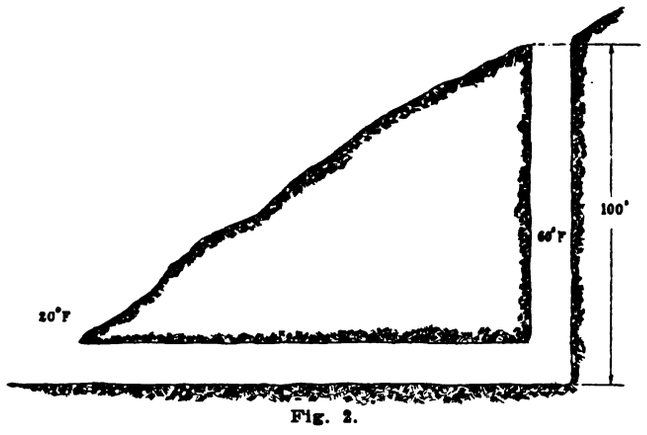

Fig. 2.

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ture there must be a difference in the weight of like volumes of internal and external air, and hence, with respect to each other, they must be in a condition of unstable equilibrium. Let us investigate this by assuming the outside temperature to be that first mentioned, that is 20 deg. F., the average temperature in the air shaft, see Fig. 2, being 60 deg. F. and the barometer reading 30 inches. The problem is to determine the direction in which the air will flow in the mine.

The weight of the air at the mine opening will be found by formula (a) to be,

$$w = \frac{1.3273 \times 30}{460 + 20} = .083 \text{ lbs. per cubic foot of external air.}$$

The weight of air in the shaft will be,

$$w = \frac{1.3273 \times 30}{460 + 60} = .077 \text{ lbs. per cubic foot of internal air.}$$

Since the external air is heavier the excess pressure will force the air in toward the shaft, i. e., the shaft will be an upcast.

If we now assume the outside temperature to be 90 deg. F., the inside temperature and barometric pressure remaining the same as before, we then have for the weight of air at the mine opening,

$$w = \frac{1.3273 \times 30}{460 + 90} = .072 \text{ lbs. per cubic foot of external air.}$$

Since the external air is now lighter than the mine air, the pressure of the air in the shaft will force a current toward the mine opening, i. e., ventilation is now reversed and the shaft has become a downcast.

The assumptions made in this case serve well to illustrate the changeableness of natural ventilation. In the transition period between extremes of heat and cold, and frequently throughout one or more periods in each summer day, the outside and inside air will be at the same temperature. The weights of air being the same, the pressures will be balanced and flow of air will cease. Natural ventilation is at its greatest usefulness when the weather is either extremely hot or cold. While it is the most economical system that can be used from the power standpoint, it is undependable since subject to fluctuation which can not be controlled.

COEFFICIENT OF FRICTION

The value of the coefficient of friction has been determined by various investigators, and since no two mines are quite the same, there is, as might be expected, a considerable variance in result. The following table is taken from the Coal Miners' Pocketbook:

Table of Various Coefficients of Friction of Air in Mines

J. J. Atkinson's Treatise	.0000000217
A. Devillez in Ventilation des Mines	
Forchies	.000000008211
Crachet-Picquery	.000000008928
Grand Baisson	.000000008611
Used in Ventilation des Mines	.000000009511
Arched Tunnels	.000000002113
Along a Working Face of Coal	.000000014266
G. G. Andre, Atmosphere of Coal Mines	.000000022424
Peclet, Cheminee (Devillez, p. 112)	.000000003697
D. K. Clark	.000000002272
According to Goupilliere's Cours d' Exploitation des Mines	
D'Aubuisson	.000000001955
Navier	.000000001872
W. Fairley	.00000001
J. Stanley James	.000000000929
D. Murgue	.000000008242

Thomas W. Fitch, Jr., gives the following values of k:*

For galvanized steel piping	.0000000024
For air passages which are concreted, wood lined, or of exceptional smoothness, and untimbered, straight, regular and free from obstructions	.0000000036
For air passages which are untimbered, fairly smooth, straight, unobstructed and regular in size	.0000000073
For air passages which are untimbered and moderately crooked, irregular, obstructed and rough	.0000000109
For air passages which are timbered, but otherwise fairly smooth, straight, unobstructed and regular in size	.0000000146
For air passages which are timbered and moderately crooked, irregular, obstructed and rough	.0000000182
For air passages which are timbered, and very crooked, irregular and rough	.0000000219

*Proceedings West Virginia Coal Mining Institute, 1910.

The highest of these values, .000000022424, as given by Andre, is about twelve times the lowest, .000000001872, as given by Navier. A computation for entry resistance, using each formula in turn, would show a like variance in results. It is plain, therefore, that before accurate results can be expected from a mathematical computation of resistance, the value of "k" for that particular mine must be known.

The value of k, .0000000217, as given by Atkinson, is the one best known and most used, though in all probability it is far too high to fairly represent the average mine. Long usage, it seems, has given it acceptance, to such an extent that there has been little disposition on the part of investigators to determine the real value for a mine, or a group of mines operating under like conditions. In justification of the use of an inordinately high coefficient it is urged that it is preferable to using a coefficient too low, and this is unquestionably true. Superior to either, however, is the rightful value.

The factors which create a high value for the coefficient of friction in the mine are:

1. Entries littered with falls of top rock, or obstructed with old mine cars, etc.
2. Rough and irregular sides, top or bottom, due frequently to carelessness in undercutting and blasting.
3. Useless timbering.
4. Overcasts having no filling of rock behind the side walls to provide an easement for the air.
5. Sharp turns in the air course.
6. Sudden contractions and expansions.

Anything which creates undue resistance should be avoided, for the higher the coefficient of friction the greater will be the power required to move the air.

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HUMIDITY OF MINE AIR MEASURED BY THE HYGROMETER

What the Wet-and-Dry-Bulb Hygrometer Indicates

The wet-and-dry-bulb hygrometer shows the difference between the readings of the two thermometers. The dry-bulb thermometer, of course, indicates the actual temperature of the air. The reading of the wet-bulb thermometer is lowered by the evaporation of the water from the little sack surrounding this bulb, and which is kept moist by the water drawn up through the wick from the vessel below.

The difference of temperature indicated by these two thermometers depends on the rapidity of the evaporation of the water from the wet bulb. The evaporation is more rapid in dry than in wet air; and the difference of reading is, thus, an index or measure of the degree of saturation of the air. When the air is fully saturated with moisture there is no evaporation from the wet bulb and the readings of the two thermometers are the same. The difference increases with the dryness of the air.

Relative Humidity of Air

As previously explained the relative humidity of air is expressed by the ratio of the actual vapor pressure in the air at the time, to the saturated vapor pressure. The following table gives the percentage of saturation or the hygrometric state of air for various differences of readings, at different temperatures.

Difference Between Dry and Wet Bulb

Reading of dry bulb ther.	Degrees																					
Degrees	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	17.5	18	18.5	19	19.5	20	20.5	21
	Relative Humidity																								
65	95	90	85	80	75	70	66	62	57	53	48	44	40	36	32	28	25	23	21	19	17	15	13	12	10
66	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	29	26	24	22	20	18	17	15	13	11
67	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	30	27	25	23	21	20	18	16	15	13
68	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	31	28	26	24	23	21	19	17	16	14
69	95	90	86	81	77	72	68	64	59	55	51	47	44	40	36	32	29	27	25	24	22	20	19	17	15
70	95	90	86	81	77	72	68	64	60	56	52	48	44	40	37	33	30	28	26	25	23	21	20	18	17
71	95	90	86	82	77	73	69	64	60	56	53	49	45	41	38	34	31	29	27	26	24	22	21	19	18
72	95	91	86	82	78	73	69	65	61	57	53	49	46	42	39	35	32	30	28	27	25	23	22	20	19
73	95	91	86	82	78	73	69	65	61	58	54	50	46	43	40	36	33	31	29	28	26	24	23	21	20
74	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34	32	30	29	27	25	24	22	21
75	96	91	87	82	78	74	70	66	63	59	55	51	48	44	41	38	34	33	31	30	28	26	25	23	22
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42	38	35	34	32	30	29	27	26	24	23
77	96	91	87	83	79	75	71	67	63	60	56	52	49	46	42	39	36	34	33	31	30	28	27	25	24

To use the table, find the observed temperature of the air, in the left-hand column, and the difference of the observed readings of the wet-and-dry-bulb thermometers, at the top of the table; the corresponding number in the table is the percentage of saturation which expresses the degree of humidity of the air. For example, if the dry-bulb temperature is 70 deg. and the wet-bulb 64 deg. F. the difference of readings is 6 deg. and the corresponding humidity as taken from the above table is 72 per cent.

The Application to Mining

The moisture which air can carry varies directly with its temperature, that is, air at 80 deg. F. can carry more moisture than air at 20 deg. F. Let us assume the average temperature of mine air to be 60 deg. F. the whole year around. During the warm summer months air entering the mine at 80 deg. F. comes in contact with the top and sides of the drift and is cooled to the temperature of the mine. Because of the drop of 20 degrees in temperature, the quantity of water vapor the air can carry is reduced and moisture may be deposited on the top and sides, on the same principle as dew is deposited on blades of grass during the warm summer nights. The mine is then said to be "on a sweat." If the warm air entering the mine is at a low humidity, that is, it is carrying but a small percentage of water vapor, the effect of a drop of 20 degrees in temperature may be merely to raise the humidity of the air, but not, however, to the dew point. In this event no moisture will be deposited.

In the winter months the conditions are reversed. Air entering the mine, say at 20 deg. F., gradually reaches a temperature equal to that of the mine. With each increment in temperature given to the air its capacity for moisture is increased, and this moisture is supplied as the air passes over the wet sections of the mine. The effect is to make these sections dry and dusty, which increases danger from fire and breathing of rock dust by men. For this reason it is advocated that in all mines which are dry and dusty, moisture be supplied to the mine during the cold months by means of exhaust steam, sprays, sprinkling with a hose or by a pump mounted on a movable truck and forcing the water through pipes or sprays under pressure.

VENTILATION EQUIPMENT*

In metal mines there are many parts of the mine, such as the face and stopes, raises and winzes, that it is usually not feasible to ventilate with the main current, even when a mechanical ventilating system is in use. To ventilate such workings, it has been usual to use portable motor-driven fans, connected to sheet-iron pipes. At the North Butte mines, Butte, Montana, Sirocco fans are used connected to canvas tubing. The successful application of canvas tubing to ventilating was made feasible by the flexible coupling and method of suspension invented by Mr. Braly.

Canvas tubing possesses the following important advantages over metal pipes:

1. It is much more easily and quickly installed, and when not carrying air hangs collapsed at the side of the working, where it takes up very little room.

2. Since it hangs collapsed during the blasting of the round and is expanded by the air pressure of the fans turned on immediately afterwards, ventilation can be carried close to the face. In ordinary cross-cuts, it is impossible to keep metal pipe closer than 100 ft. to the breast because the concussion in blasting tears it down; even then, unless the end is tightly covered with a board, the pipe may collapse for a length of 60 to 70 ft.

3. Falls of rock in a drift ruin metal pipe permanently, whereas canvas pipe frequently is not even punctured; or if damaged it can easily and quickly be repaired.

4. Canvas tubing can, without the slightest difficulty, be run through stopes, over and around timber, and in numerous places where the fitting

*Trans. A. I. M. E., 1920.

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of metal pipe would be too slow and expensive to be feasible.

5. The miners can put on lengths of canvas tubing and deflect the air so as to blow directly upon them, thus removing the layer of warm air surrounding their bodies. This is of great importance, especially on the lower levels where rock temperatures are high.

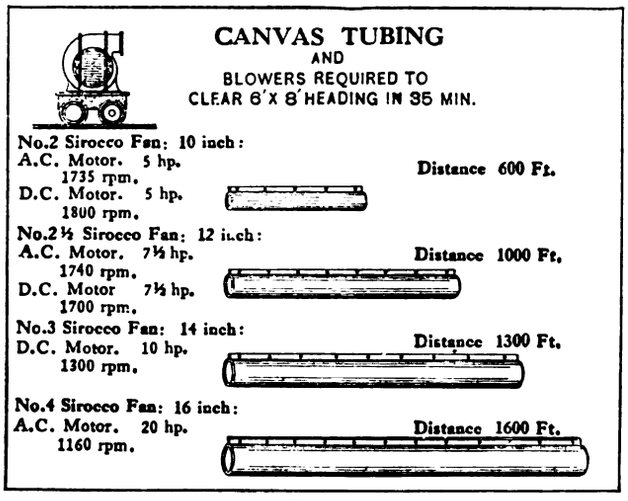

Fig. 4

Of course, the friction in canvas tubing is greater than in an absolutely tight metal pipe of the same diameter; but in ordinary practice the reduction of volume and pressure due to higher friction in the canvas tubing is considerably less than the reduction due to leaks in metal pipe. It is difficult to get any satisfactory ventilation from an ordinary metal pipe 1,000 ft. long, whereas excellent ventilation has been obtained from canvas tubing over 2,400 ft. long. The size of tubing and the corresponding size of fan are determined by the size of the workings to be ventilated and the distance the air must be carried. Standards based on clearing a working face within 35 minutes after blasting are shown in Fig. 4. The equipment can be used to ventilate at a much greater distance by consuming a correspondingly longer time.

Both alternating and direct-current motors are used for driving the fans; direct current is preferable since the motors can be attached to the trolley lines anywhere in a few minutes time. The best practice is to use a larger motor than the rating of the fan specifies, in order to allow a margin of safety for overheating where it is necessary to use it under temperature conditions above normal. Fans 2, 2½ and 3 are self-contained, being mounted on trucks complete with starting apparatus, ready to connect the transmission wire. The dimension mountings permit lowering the mounted fans on the cages without taking apart. The No. 4 Sirocco fan is too large to lower on the mine cage without taking apart; hence, it is not mounted on a truck, but where used is placed. Practically all the fans used are the smaller size, since most of ventilating distances are comparatively short.

PRINCIPLES OF VENTILATION*

No. 1—That all working shafts be downcasts, smooth-lined and fire-proofed.

It is highly desirable that all working shafts be downcasts. Should any gas form in a mine (either from explosives, mine fires, or stratas generally) it naturally would seek its way to surface through the upcast shaft. Were the main working shaft an outlet, instead of an intake, it would greatly add to the danger, as a large number of the men would naturally endeavor to leave the mine by the main working shaft, (through which the gas was exiting to surface), rather than seek safety through some auxiliary and less familiar shaft. Moreover, there is always considerable work being done through the main shaft, and, if it is an upcast, the men employed in its vicinity are always at a disadvantage as they work continually in vitiated and impure air, which has already passed through a large proportion of the main workings.

In cases where sufficient shafts have been sunk on the property to take care of the entire ventilating system—both intake and outlet air—without using the main working shafts, then these latter may remain neutral. However, even in such cases, it is more desirable to make these shafts slight downcasts, in order to maintain a freshness in the air, and provide for emergencies in the event of possible mine fires, which might turn a neutral into an upcast shaft.

It has long been recognized that a smooth-lined shaft does not offer the same amount of resistance to the air currents, as that offered by the ordinary timbered shaft. Experiments show that a very much larger volume of air can be passed through a smooth-lined shaft, than through an ordinary shaft, using the same amount of horsepower in each case. Smooth-lining may be accomplished by the use of ordinary boards, but such construction does not constitute a fire-proof shaft. The most satisfactory form of smooth-lining, which is also fireproof, is the concrete shaft. Another form of smooth lining and fire-proofing is the use of brick, or faced rock and mortar. Still another form, is the use of gunite and metal lath, also concrete slabs, which are placed flush with the shaft timbers and cemented in.

The value of fire-proofing main working shafts cannot be questioned, as numerous accidents have occurred in the past which have demonstrated the necessity of having all downcast shafts fireproofed, as an insurance measure against the loss of life and property.

If, however, the life of a shaft, or of the mine itself, does not justify the cost of a first-class fireproof shaft, some other method of fire protection should be adopted. That most generally used, is the installation of water sprays (controlled from surface) in both the shaft and shaft stations. In addition to such a spraying system, a complete control of the ventilating currents on each level, by means of fire doors, must be provided. These should also be controlled from surface. Unless an absolute check of the ventilating current, by means of these doors, is obtained, the water from the sprays would, in the case of a shaft fire, force the smoke and gas into the workings.

No. 2.—The areas of all downcast working shafts should be large enough to permit a sufficient

*Submitted to National Standardization Conference by Committee on Ventilation.

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volume of ventilating air to pass through without an excessive velocity. Where working shafts are already in operation, other provisions must be made, but when the sinking of new working shafts is contemplated, this point should be borne in mind.

No. 3.—In all downcast shafts, the cages should be provided with gratings on the bottom, in order to offer as little resistance to the air as possible, and the bonnets should also be made of fine, strong screening instead of sheet iron, in order to allow air to pass through.

No. 4.—Provision should be made at all downcast shafts for fireproof head frames, such as steel or concrete, and all buildings adjacent to shaft collars should also be fireproofed.

No. 5.—As, in general, there is considerable air movement in all shaft stations, and as the majority of shaft fires have occurred in such locations, all stations should be fireproofed simultaneously with the shafts.

No. 6.—Where shafts are sunk for ventilation purposes only, such shafts should be circular and fireproof. The use of the circular shaft has been found through years of experience, to be preferable to the square or rectangular shaft, on account of its smaller perimeter for the same area.

No. 7.—The total outlet area of a mine should always be larger than the total intake area. Air entering a mine usually rises in temperature in its passage through the workings, thus increasing its volume. Therefore, the larger the final outlets of the mine, the less will be the resistance, and less power will be required to force the given volume of air through the workings.

No. 8.—It is advisable that the velocities in main operating shafts do not exceed 1500 feet a minute. This, however, does not apply to shafts which are used for ventilation only, and which are not used as traveling ways for men, as the velocity in these latter shafts may be much higher.

No. 9.—Wherever the mining method permits, the ventilating air should be drawn off on various levels, rather than forcing the entire volume down to the bottom of the shaft and allowing it to exhaust upwards through the workings. The former method will allow a more even distribution of air throughout the entire mine workings, with a great deal less friction than the latter. Moreover, in the latter method, where the air is carried to the lowest level before being split up, the entire volume is, first of all, drawn through restricted areas for great distances, which naturally results in the maximum amount of friction.

Secondly, the impurities and moisture taken up by the air in the lower workings are then carried upwards continuously, through all the upper levels, having not only a detrimental effect on the men, but keeping the upper workings in a moist and usually hot condition.

It has long been recognized that wherever possible, the division of a mine into separate ventilating districts, or air splits, is most advantageous. These currents of air, should be conducted as directly as possible to the upcast shafts.

No. 10.—It is recommended that the metal mines be urged to adopt standard areas for tunnels, drifts, passage-ways, and raises, which, while conformable with economy, will permit the maximum flow of air, with the minimum friction.

The use of frequent raises, in ore bodies mined by practically every underground mining system, has been found to be most advantageous from an efficiency standpoint, as the greater the number of raises, the less the hand labor required in passing the ore, and the greater the efficiency.

No. 11.—So-called "abandoned workings" in metal mines, from which the ore has not been entirely extracted, or which have future prospect values, should be provided with some form of economical regulator door or stopping, which, while cutting off the major flow of air from entering these so-called "abandoned workings," allows sufficient air to pass through to prevent decay. Abandoned workings which are filled with waste, or cave of their own weight, and from which all ore has been extracted, require no ventilating air, and generally seal themselves.

No. 12.—In all new sections of a property, which are being developed for stoping purposes, the ventilation should be planned simultaneously with the stoping, and expanded along with the mining operations.

No. 13.—For many years, the coal miners of both Europe and America, have recognized the great importance of air movement, not only in main traveling ways, but also at the various working faces. To secure such movement at the working faces in metal mines is far more difficult than in coal mining. However, the reat test of an efficient primary metal mine ventilating system is the number of working faces which are provided with adequate air movement. This can be obtained through judicious coursing of the air currents, by means of air connections advantageously located, the use of stoppings, ventilating doors, brattices, occasional overcasts, etc.

No. 14.—In general, all mines should be provided with a primary and a secondary ventilating system. The primary ventilating system to consist of large mine fans, advantageously located according to local conditions, and, if efficient, to thoroughly ventilate from 75% to 95% of the workings. The secondary ventilating system to consist of small blowers with ventilating pipe, for use in dead ends only, such as long drifts, raises, or stopes located in isolated sections of the mine.

The secondary ventilating system should never be allowed to supercede the primary ventilating system, as such procedure is not only inefficient but very costly. All efforts should be directed towards improving the primary ventilating system, in order to have it ventilate as much of the mine as possible.

No. 15.—The use of either pressure or exhaust systems cannot be standardized, but must be decided according to local conditions at the mine about to be ventilated. This also applies to the location of fans for primary ventilating systems. Certain conditions may require surface installations, while other mines may be served more adequately by fans installed underground. The design and size of fans, volume of air, and water gauge, all depend largely on local conditions.

No. 16.—In general, large mine fans should be reversible.

No. 17.—In mines which are so dry that dust is readily formed, spraying systems should be installed to lay the dust and humidify the mine air sufficiently to prevent excessive evaporation.

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MINE VENTILATION FORMULAS

To illustrate the use of the formulas, we take as an example an underground road, 5 ft. wide and 4 ft. high, and 2,000 ft. in length, and calculate the value of each symbol or letter, assuming a velocity of 500 ft. per minute.

	Symbol	Value of Symbol for this Particular Example
Area of airway 5 ft. x 4 ft.)	a	20 sq. ft.
Horse power	h	2.959 H. P.
Coefficient of friction	k	.0000000217
Length of airway	l	2,000 ft.
Perimeter of airway, 2(5 ft. + 4 ft.)	o	18 ft.
Pressure (lb. per sq. ft.)	p	9.765 lb.
Quantity of air (cu. ft. per min.)	q	10,000 cu. ft.
Area of rubbing surface	s	36,000 sq. ft.
Units of work per minute (power)	u	97,650 ft.-lb.
Velocity (ft. per min.)	v	500 ft.
Water gauge	i	1.8788 in.
Equivalent orifice of the mine	A	2.919 sq. ft.
Potential for power	X_u	217.16 units
Potential for pressure	X_p	3,200 units
Weight of 1 cu. ft. of downcast air	w	.08098 lb.
Motive column (downcast air)	M	120.5 ft.
Depth of furnace shaft	D	306.77 ft.
Aver. temp. of upcast column	T	350° F.
Aver. temp. of the downcast column	t	32° F.

On the right side of each formula, the various calculations, based on the example given, are worked out in figures.

To Find:	No.	Formula	Specimen Calculation
Rubbing surface of an airway. (Sq. ft.)	1	$S = lo$	$2{,}000 \times 18 = 36{,}000$ sq. ft.
Area of an airway. (Sq. ft.	2	$a = \frac{q}{v}$	$\frac{10{,}000}{500} = 20$ sq. ft. of area.
Velocity. (Ft. per min.)	3	$v = \frac{q}{a}$	$\frac{10{,}000}{20} = 500$ ft.
	4	$v = \sqrt[3]{\frac{u}{ks}}$	$\sqrt[3]{\frac{97{,}650}{.0000000217 \times 36{,}000}} = 500$ ft.
	5	$v = \sqrt{\frac{pa}{ks}}$	$\sqrt{\frac{9.765 \times 20}{.0000000217 \times 36{,}000}} = 500$ ft.
	6	$v = \frac{u}{pa}$	$\frac{97{,}650}{9.765 \times 20} = 500$ ft.
Pressure. (Lb. per sq. ft.)	7	$p = \frac{ksv^2}{a}$	$\frac{.0000000217 \times 36{,}000 \times (500)^2}{20} = 9.765$ lb.
	8	$p = \frac{ksq^2}{a^3}$	$\frac{.0000000217 \times 36{,}000 \times (10000)^2}{(20)^3} = 9{,}765$ lb
	9	$p = \frac{u}{q}$	$\frac{97{,}650}{10{,}000} = 9.765$ lb.
	10	$p = Mw$	$120.58 \times .08098 = 9.765$ lb.
	11	$p = 5.2\,i$	$5.2 \times 1.87788 = 9.765$ lb.
	12	$p = \frac{q^2}{X_u^3}$	$\frac{(10{,}000)^2}{(217.16)^3} = 9.765$ lb.
	13	$p = \frac{q^2}{X_p^2}$	$\frac{(10{,}000)^2}{(3{,}200)^2} = 9.765$ lb.
Water gauge. (Inches.)	14	$i = \frac{p}{5.2}$	$\frac{9.765}{5.2} = 1.87788$ in.
Resistance of an airway.	15	$pa = ksv^2$	$.0000000217 \times 36{,}000 \times (500)^2 = 195.3$ lb.
(Total pressure, lb.)	16	$pa = \frac{u}{v}$	$\frac{97{,}650}{500} = 195.3$ lb.
Quantity. (Cu.ft.per min.)	17	$q = av$	$20 \times 500 = 10{,}000$ cu. ft.
	18	$q = \frac{u}{p}$	$\frac{97{,}650}{9.765} = 10{,}000$ cu. ft.
	19	$q = \sqrt{\frac{pa}{ks}} \times a$	$\sqrt{\frac{9.675 \times 20}{.0000000217 \times 36{,}000}} \times 20 = 10{,}000$ cu. ft.
	20	$q = \sqrt[3]{\frac{u}{ks}} \times a$	$\sqrt[3]{\frac{97.650}{.0000000217 \times 36{,}000}} + 20 = 10{,}000$ cu. ft.
	21	$q = X_u \sqrt[3]{n}$	$217.16 \sqrt[3]{97{,}650} = 10{,}000$ cu. ft.
	22	$q = \sqrt[3]{X_p^2 u}$	$\sqrt[3]{(3{,}200)^2 \times 97{,}650} = 10{,}000$ cu. ft.
	23	$q = X_p \sqrt{p}$	$3{,}200 \sqrt{9{,}765} = 10{,}000$ cu. ft.
Units of work per minute, or power on the air. (Ft.-lb. per min.)	24	$u = avp$	$20 \times 500 \times 9.765 = 97{,}650$ ft.-lb.
	25	$u = qp$	$10{,}000 \times 9.765 = 97{,}650$ ft.-lb.
	26	$u = ksv^2$	$.0000000217 \times 36{,}000 \times (500)^2 = 97{,}650$ ft.-lb.
	27	$u = \frac{ksq^2}{a^2}$	$\frac{.0000000217 + 36{,}000 \times (10{,}000)^2}{(20)^2} = 97{,}650$ ft.-lb.
	28	$u = h\,33{,}000$	$2.959 \times 33{,}000 = 97{,}650$ ft. lb.
	29	$u = \frac{q^2}{X_u^2}$	$\frac{(10{,}000)^2}{(217.16)^2} = 97{,}650$ ft.-lb.
	30	$u = \frac{q^2}{X_p^2}$	$\frac{(10{,}000)^2}{(3{,}200)^2} = 97{,}650$ ft.-lb.
Horse power.	31	$h = \frac{u}{33{,}000}$	$\frac{97{,}650}{33{,}000} = 2.959$ H. P.
Power potential. (Units.)	32	$X_u = \frac{a}{\sqrt[3]{ks}}$	$\sqrt[3]{\frac{20}{.0000000217 + 36{,}000}} = 217.16$ units
	33	$X_u = \sqrt[3]{\frac{q^2}{p}}$	$\sqrt[3]{\frac{(10{,}000)^2}{9.765}} = 217.16$ units.
	34	$X_u = \frac{q}{\sqrt[3]{u}}$	$\frac{10{,}000}{\sqrt[3]{97{,}650}} = 217.16$ units.
Pressure potential (Units.)	35	$X_p = a\sqrt{\frac{a}{ks}}$	$20\sqrt{\frac{20}{.0000000217 \times 36{,}000}} = 3{,}200$ units.
	36	$X_p = \frac{q}{\sqrt{p}}$	$\frac{10{,}000}{\sqrt{9.765}} = 3{,}200$ units.
Equivalent orifice. (Sq. ft.)	37	$A = \frac{.0004q}{\sqrt{i}}$	$\frac{.0004 \times 10{,}000}{\sqrt{1.87788}} = 2.919$ sq. ft
Motive column, downcast air. (Feet.)	38	$M = D \times \frac{T - t}{459 + t}$	$306.77 \times \frac{350 - 32}{459 + 350} = 120.5$ ft.
	39	$M = \frac{p}{w}$	$\frac{9.765}{.08098} = 120.5$ ft.
Motive column, upcast air. (Feet.)	40	$M = D \times \frac{T - t}{459 + t}$	$306.77 \times \frac{350 - 32}{459 + 32} = 198.7$ ft
	39	$M = \frac{p}{w}$	$\frac{9.765}{.04915} = 198.7$ ft.

Coal and Metal Miner's Pocketbook.

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INSTALLATION OF FANS

There are four general types of fan installations. See Fig. 3.

1. Single inlet exhausting, as shown in Arrangements 1 and 2.

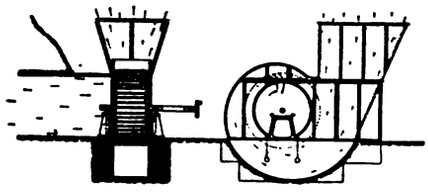
2. Double inlet exhausting, as shown in Arrangements 5 and 7.

3. Double inlet blowing, as shown in Arrangements 4 and 10.

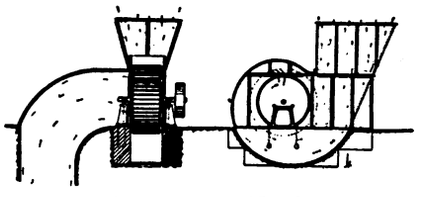
4. Double inlet reversible, as shown in Arrangements 3, 6, 8 and 9.

Frequently the reversal of the ventilating system is referred to as "reversing the fan." This is an erroneous and misleading expression, as the direction of rotation of the fan wheel remains the same, no matter whether running exhaust or blowing. It is solely the air current that is reversed, and this is done by closing and opening certain doors which control the entrance of air to the eye of the fan and its delivery either to the evase chimney or the fan drift. See arrangements 3, 6, 8 and 9.

In several of the arrangements shown, it will be noted that the fan is set in a direct line with the air course. This is not to be recommended, since in the event of an explosion, the fan would be in the direct path of violence and likely to be badly damaged or totally destroyed. A better plan is to set it to the side. In addition to the protection thus gained, explosion doors may be provided which would be thrown open by the force of the blast and relieve the pressure before it reaches the fan. The presence of such doors is indicated in arrangements 8 and 10.



Arrangement No. 1.



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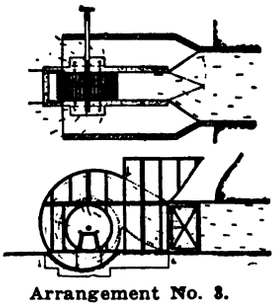
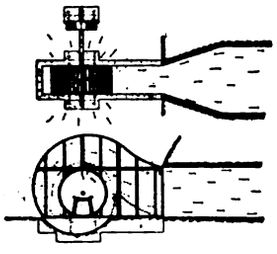


Arrangement No. 3.



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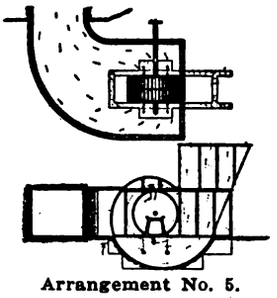
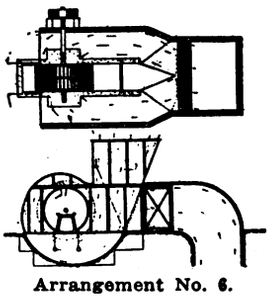
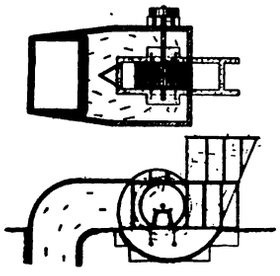


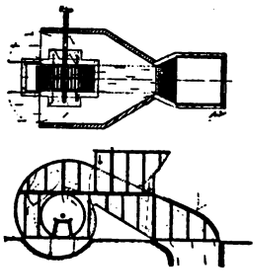
Arrangement No. 5.



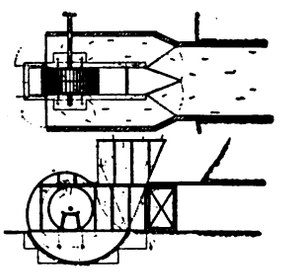
Arrangement No. 6.



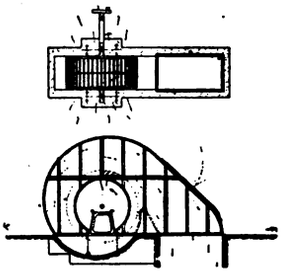
Arrangement No. 7.



Arrangement No. 8.



Arrangement No. 9.



Arrangement No. 10.

Fig. 36—General Arrangement of Fans.

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BUCKEYE BLOWER COMPANY

COLUMBUS, OHIO

BRANCH OFFICES

258 Candler Annex, Atlanta, Georgia 324 Monadnock Block, Chicago, Illinois

Buckeye Centrifugal Mine Fans

Design

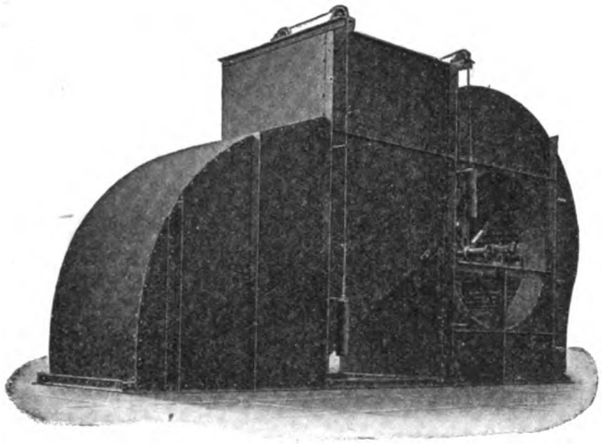
Buckeye Fans are correctly designed for efficient operation, and substantially built of the best materials to withstand the severe service and corrosion so destructive to mining equipment.

Sizes

Buckeye Mine Fans are built in all sizes, double or single inlet, with housings suitable for either blowing or exhausting the air, or for both blowing and exhausting, which type is known as a reversible fan. There is a Buckeye Fan to meet every condition of mine ventilation.

The bearing is the only wearing part in a fan, and if the steel is given adequate protection against corrosion, the life of the fan is limited only by the life of the bearings.

Buckeye trunnion bearings are of the self-aligning type and chain oiled from a large oil reservoir. Wear is thus reduced to a minimum and ample provision is made to take up such wear as it occurs. Ball Bearings are furnished for all sizes, if desired.



Buckeye Reversible Multiblade Fan

A Buckeye installation is compact and rugged in construction, and above all, absolutely reliable in operation. What does a shut-down mean to you? Your Buckeye Fan means dependable service at all times.

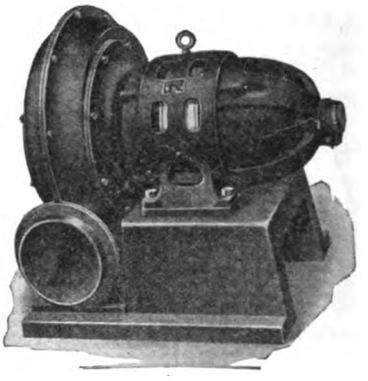
SEND FOR BULLETINS

Buckeye Cast Iron Blowers

When direct motor driven, are universally used in connection with flexible tubing for ventilation. The double inlet type fans or blowers are used for furnishing blast to forge fires and furnaces.

They may be used either as single inlet exhausters or double inlet blowers.

They can be furnished for belt drive, or direct connection to standard electric motors. They may be mounted on the floor as bottom horizontal discharge fans; hung from the ceiling as top horizontal discharge fans or mounted on the wall as vertical up or down discharge.



Left-Hand Direct Motor Drive

In ordering these fans, we should have the following information, which will enable us to give your inquiry a prompt and definite answer:

Hand of discharge,
Service required of fan,
Air delivery wanted,
Static pressure or resistance of Mine,
Length of tubing required,
Any other information available.

To determine the hand of these fans, face the pulley side, then if discharge is on left, fan is left hand, and if on right, fan is right hand.

Mining is your business; Ventilation is ours. Our Fan engineers are at your service. Send us your problems. Our suggestions or recommendations obligate you in no way.

CAST IRON BLOWER TABLE OF CAPACITIES FOR MINE VENTILATION

Fan Size	½ Oz.			1 Oz.			1½ Oz.			2 Oz.		
	R. P. M.	C. F. M.	B. H. P.	R. P. M.	C. F. M.	B. H. P.	R. P. M.	C. F. M.	B. H. P.	R. P. M.	C. F. M.	B. H. P.
5	1700	110	.02	2400	150	.07	3000	190	.15	3400	220	.25
6	1400	260	.06	1975	370	.20	2400	455	.35	2900	535	.60
8	900	520	.12	1250	750	.38	1530	900	.70	1775	1050	1.20
10	750	920	.21	1050	1300	.65	1270	1600	1.2	1475	1860	2.05

Fan Size	2½ Oz.			3 Oz.			4 Oz.			6 Oz.		
	R. P. M.	C. F. M.	B. H. P.	R. P. M.	C. F. M.	B. H. P.	R. P. M.	C. F. M.	B. H. P.	R. P. M.	C. F. M.	B. H. P.
5	3800	240	.30	4200	260	.40						
6	3100	590	.75	3400	650	1.00	4000	750	1.40			
8	2000	1150	1.50	2200	1300	2.00	2500	1500	2.75	3100	1800	4.60
10	1650	2050	2.60	1800	2280	3.40	2100	2640	4.80	2600	3250	8.10

For larger capacities, write for quotations.

Direct Motor Driven Fans With Flexible Tubing

No. 8—1200 R. P. M. 1 H. P. Motor. Use not over 200 Feet of 8" Tubing.
No. 8—1800 R. P. M. 3 H. P. Motor. Use not over 200 Feet of 8" Tubing.
No. 10—1200 R. P. M. 2 H. P. Motor. Use not over 300 Feet of 10" Tubing.
No. 10—1800 R. P. M. 5 H. P. Motor. Use not over 300 Feet of 10" Tubing.

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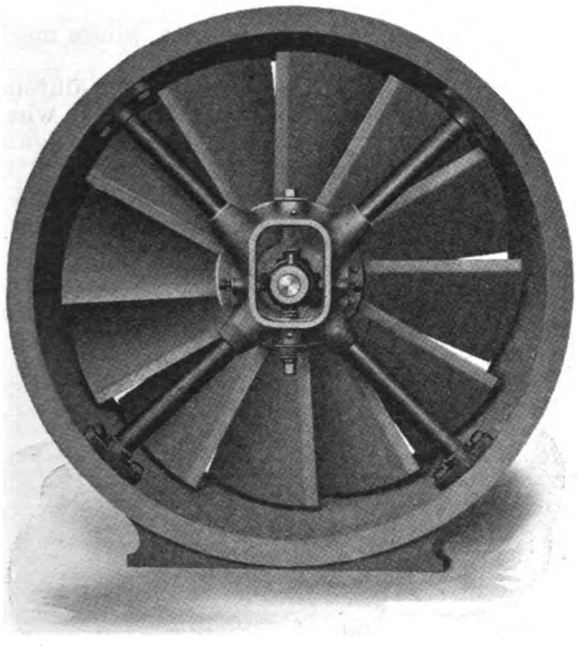
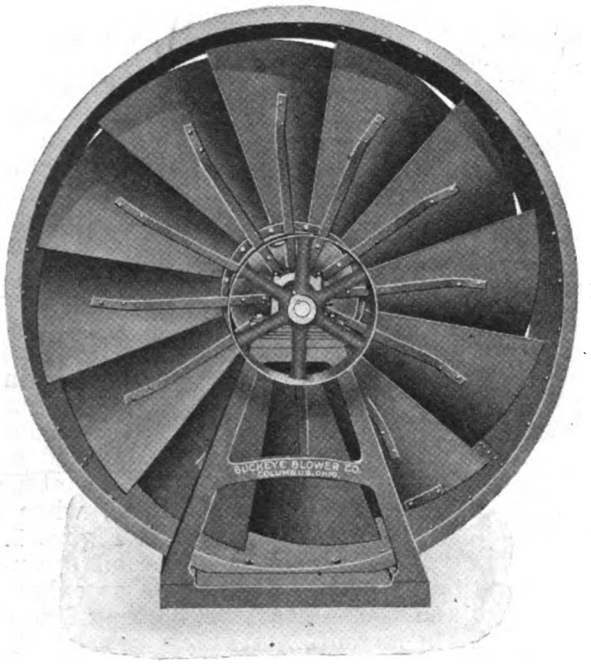
BUCKEYE

Two Rugged Types Designed for Low Pressure Service



Type A, Buckeye Disc Mine Fan, Equipped With Hyatt Bearings



Type B, Buckeye Disc Mine Fan, Showing Back View of Fan

Disc Fans

Disc Fans are recommended for small low pressure installations or for booster service. A Disc Fan is not a pressure fan.

Buckeye Disc Fans are too well known to need any description. They are carried in stock in the three, four, five, six and eight feet sizes with fan-wheel set to draw the air over the pulleys. Other sizes are built to order, and if so ordered any size can be assembled to blow over the pulley.

Where the standard pulley is not desired, we can furnish the proper size pulley required.

Service

Buckeye service is unequaled. The leading supply house in your district carries these fans in stock; prompt shipment can be made from one of our dealers, or direct from factory.

Remember, a fan too small for the work at hand is a constant disappointment. If in doubt order the larger one.

DISC FAN CAPACITY TABLE FOR MINE VENTILATION

Size Fan	¼" Pressure			⅜" Pressure			½" Pressure			⅝" Pressure			¾" Pressure			1" Pressure			1½" Pressure		
	C. F. M.	R. P. M.	B. H. P.	C. F. M.	R. P. M.	B. H. P.	C. F. M.	R. P. M.	B. H. P.	C. F. M.	R. P. M.	B. H. P.	C. F. M.	R. P. M.	B. H. P.	C. F. M.	R. P. M.	B. H. P.	C. F. M.	R. P. M.	B. H. P.
36	5800	450	.55	7250	560	1.10	8900	680	2.10	9800	730	2.60	11000	790	3.90	12800	910	6.10	14500	1120	12.00
42	8250	398	1.05	10000	485	1.87	11620	570	2.87	13000	640	4.00	14610	695	5.45	17000	700	8.25	20800	980	15.00
48	11100	353	1.38	13600	435	2.54	15650	500	3.90	17500	560	5.45	19700	612	7.40	22800	705	11.20	27900	860	20.00
54	14000	310	1.75	17100	380	3.18	19750	440	4.90	22000	492	6.85	24800	535	9.15	28750	620	14.26	35200	755	26.00
60	17300	280	2.14	21200	344	3.93	24400	398	6.05	27200	445	8.45	30500	485	11.40	35000	560	17.00	43500	685	33.00
72	24700	233	3.00	30000	287	5.55	34600	332	8.55	38600	371	12.00	43500	405	16.10	50500	464	25.45	61400	566	45.00
84	33500	200	4.12	41000	245	7.60	47300	274	11.70	52500	318	16.30	59500	342	22.00	69000	400	35.00	84000	483	63.00
96	43800	175	5.40	54600	215	10.10	62000	250	15.30	69000	278	21.50	78000	305	30.00	90000	350	45.00	110000	425	80.00
108	50000	155	6.25	68000	190	12.50	78000	220	19.50	88000	250	27.00	98000	270	38.00	113000	310	55.00	139000	380	100.00
120	67500	140	8.50	84000	170	15.50	97000	200	25.00	107000	225	35.00	120000	250	45.00	140000	280	70.00	170000	340	125.00

If the resistance is more than has been assumed above the resulting pressure will be higher, the volume of air delivered will be less and the horse power more.

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AMERICAN BLOWER COMPANY

DETROIT, MICHIGAN, U. S. A.

ATLANTA, GA. BOSTON, MASS. CHARLOTTE, N. C. CHICAGO, ILL. CINCINNATI, OHIO
CLEVELAND, OHIO COLUMBUS, OHIO DALLAS, TEXAS DENVER, COLO. GRAND RAPIDS, MICH.
INDIANAPOLIS, IND. KANSAS CITY, MO. MILWAUKEE, WIS. MINNEAPOLIS, MINN. NEW YORK CITY, N. Y.
OMAHA, NEB. PHILADELPHIA, PA. PITTSBURGH, PA. ROCHESTER, N. Y. SAN FRANCISCO, CAL.
SALT LAKE CITY, UTAH ST. LOUIS, MO. SEATTLE, WASH. BALTIMORE, MD.

"Sirocco" Fans

"SIROCCO" Mine Fans can be used to great advantage in metal mines and tunnels, where mechanical ventilation is required.

Their many advantages, such as low cost of installation, low power consumption and low maintenance charges, showing at the same time a high efficiency, whether used for large or small volumes at high or low water gauges, blowing, exhausting or boosting, commend them to mine operators.

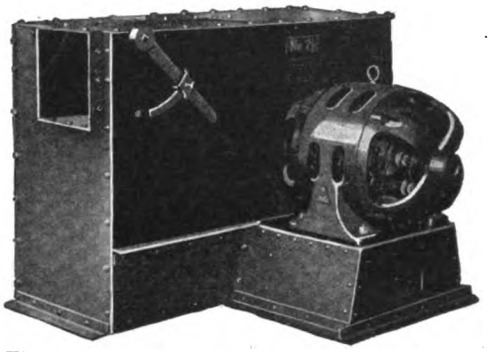


Fig. 1. Reversible "Sirocco" Fan. Motor Side.

Our long experience in the manufacture of such fans, and the fact that we have supplied such a large number of mining companies, both coal and metal mines, means we are in a position to recommend the kind of equipment which can be used to the greatest advantage.

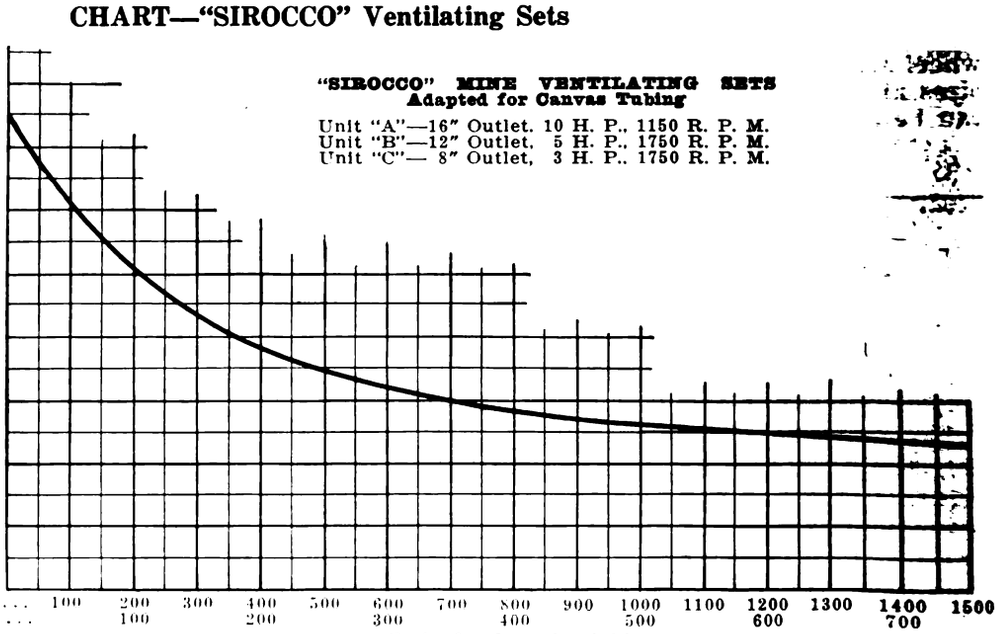
Fig. 2. "Sirocco" Fan for Use with Tubing.

REVERSIBLE "SIROCCO" Fans, when required, can be supplied for this work, as shown in Figure 1. This fan clears away very rapidly the gases given off during blasting. When used for this purpose, they operate as exhausters and pick up the smoke and fumes near the working face and discharge into the return air current. After the gas has been removed, the fan is reversed and used as a blower, thereby driving clean air to the face. Metal ducts are necessary in this class of work, as canvas tubing could not be used for exhausting.

"SIROCCO" Mine Ventilating Sets, adapted for use with canvas tubing, shown in Figure 2, can be used where it is not necessary to use the reversible "SIROCCO" Fan. These are made up in three sizes for capacities up to 7500 C.F.M., and for 8"' 12", and 16" tubing. Below we give a chart from which capacities may be determined for each size fan with different lengths and diameters of tubing:

CHART—"SIROCCO" Ventilating Sets

Scales for Cubic Feet Per Minute		
Unit "A"	Unit "B"	Unit "C"
8000	4000	2000
7000	3500	1750
6000	3000	1500
5000	2500	1250
4000	2000	1000
3000	1500	750
2000	1000	500
1000	500	250



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THE JEFFREY MANUFACTURING COMPANY

959-99 North Fourth Street, COLUMBUS, OHIO

TYPE WIRE OFFICES

New York City, Room 2008, 30 Church St. Phone Cortlandt 5417 or Cortlandt 7241 — Pittsburgh, Pa., 2111 Farmers Bank Bldg. Phone Grant 407 — Chicago, Ill., 858 McCormick Bldg. Phone Harrison 8008

Telephone any of the type-wire offices mentioned above, and your request for Jeffrey Products or Service will be at once typed over our own private wire to Columbus, and the information given you quickly and without extra cost

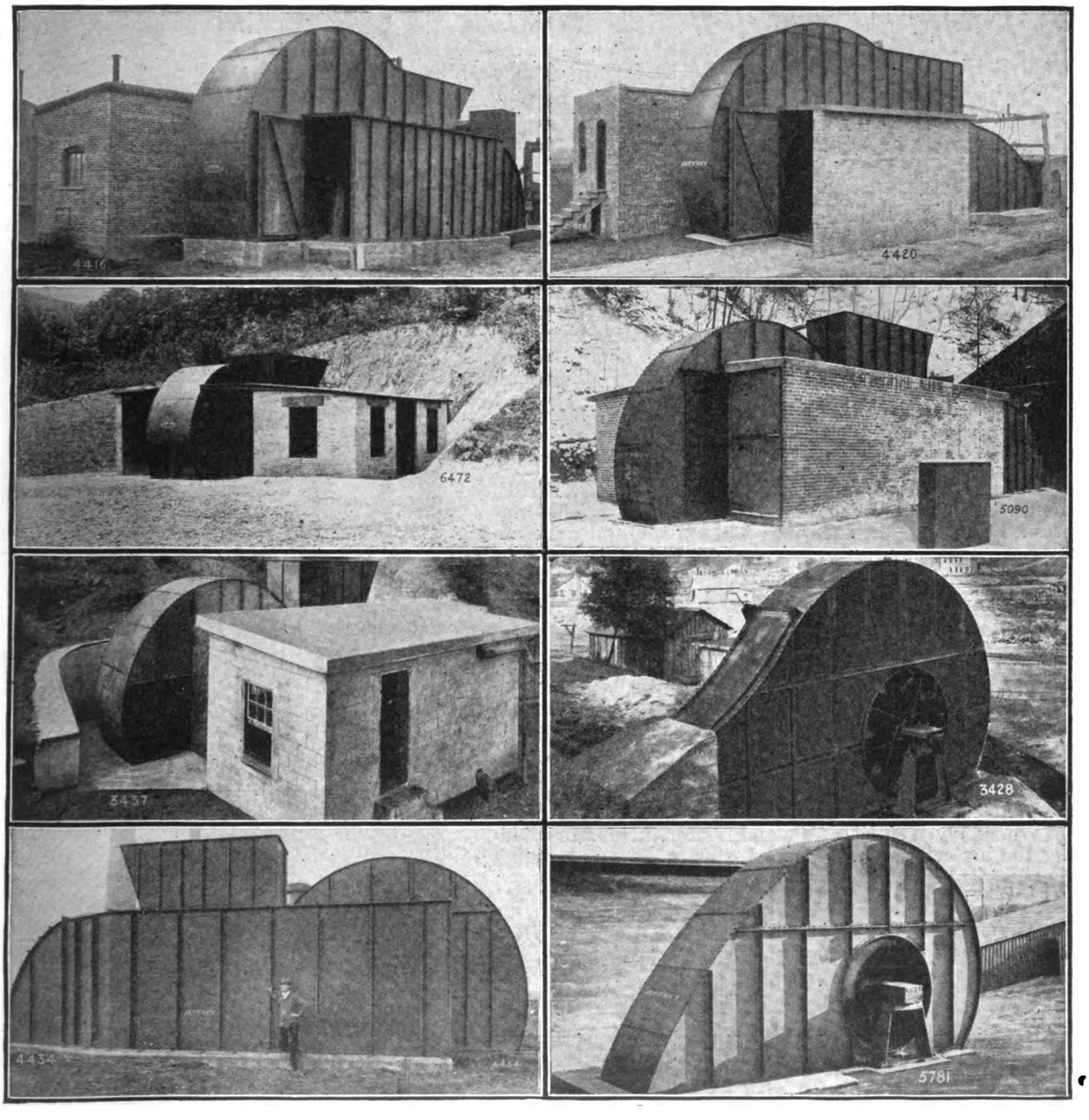
Jeffrey Ventilating Fans for Metal Mines

We build a complete line of Stepped Multi-Bladed Fans for mine installaton; also Straitflo (Disc Type Fans) for ventilation of small mines or as boosters. Fans and Exhausters for building ventilation.

The photographic illustrations below speak for themselves. Very frequently the Stepped Multi-Bladed Fan has paid for itself in one years' operation because of its power-saving factors, and efficient ventilation.

They are built in sizes from 2′ to 20′ in diameter—capacities from 10,000 to 600,000 cubic feet.

Write us for Catalog No. 280-D, the most complete ever published on the subject of Mine Ventilation, Catalog 348-F on Straitflo Fans. Also copy of report made to American Mining Congress pertaining to Ventilation of Mines.



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Bemis Bro. Bag Company

ST. LOUIS, MO.

Manufacturers of

FLEXIPIPE—A CANVAS AIR TUBING FOR METAL MINES

A REAL TIME SAVER—BETTER THAN METAL OR WOODEN PIPING

This flexible air tubing made from strong canvas, is impregnated chemically to render waterproof and air-tight. It resists dry rot and decay—has been tested to resist acid water in metal mines. Furnished in 25, 50 and 100 ft. lengths, with metal couplings at each end.

What It Does

LOWERS PRODUCTION COSTS IN ALL DRIFT, SHAFT AND RAISE WORK. Carries a fresh supply of air from a fan or blower right against the face in drifts, shafts, raises and stopes. Clears fumes immediately, eliminates lost time and lowers temperatures. Pays for itself in several hundred feet of drift work.

How Installed

FLEXIPIPE is hung from an overhead wire by means of metal hooks which are supplied with it. It can be suspended from any ordinary wire not less than 1/8" diameter, attached to "sprags" placed at about 15-foot intervals in the roof. No tools are required other than a hammer and a pair of pliers.

Coupling

To put together any two lengths of FLEXIPIPE, compress one coupling and insert into the other. The compressed coupling when released will expand and make an airtight joint.

Blower Outfit

FLEXIPIPE is used with a pressure blower. An outfit with blower directly connected to motor, similar to the one shown in the illustration, gives the best results. We can furnish this complete, as illustrated, with starting switch, leads, base and a motor suitable for the voltage in your mine.

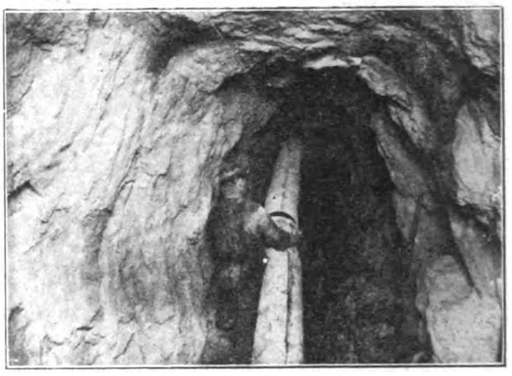
Accessories

We supply metal T's, Y's and L's for turning or dividing the air current, also special collars for suspending the tubing vertically in shafts.

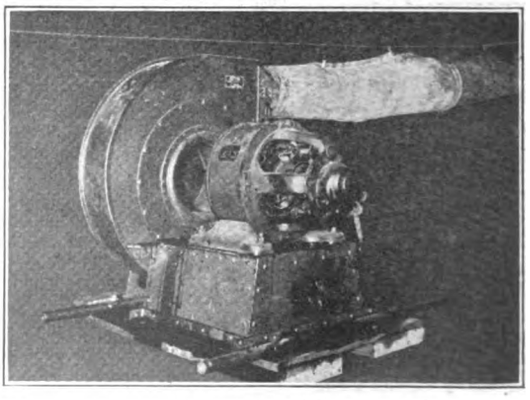
IF YOU WANT TO GREATLY REDUCE YOUR PRODUCTION COSTS, WRITE AT ONCE FOR FULL PARTICULARS

OUR NEW IMPROVED TUBING — TESTED TO RESIST ACID WATER IN METAL MINES — WITHSTANDS DRY ROT AND DECAY.

Illustrating the Compactness of 100 Ft. of 12" FLEXIPIPE



To Connect Two Sections Partly Remove from Suspension Wire to Facilitate Handling



Complete Model "B" Blower Outfit

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E. I. du Pont de Nemours & Company, Inc.

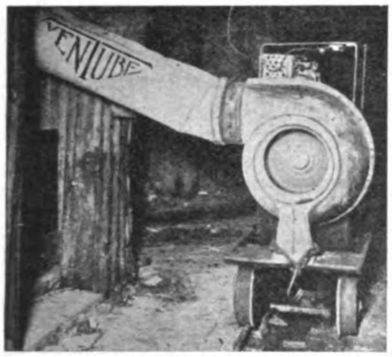
Fabrikoid Division, NEWBURGH, NEW YORK

VENTUBE

A flexible ventilation tubing made of an extremely rugged fabric that is waterproof, fungus-proof and highly resistant to all acid and alkaline conditions met in mining operations. Its long service life makes it very efficient from the standpoint of cost and maintenance. Many Ventube installations are in use and have proved their value in increasing production by providing better working conditions underground. (Write us for booklet on Ventube).

Sizes, Fittings, Couplings

Ventube is supplied in standard length tubes of 25, 50 and 100 feet each, in standard diameters of 8, 12 and 16 inches. Fittings to meet all requirements are supplied in the same diameters. (See tables for weights and dimensions).



Portable Fan and Ventube Blowing Air Into a Stope. Such Equipment Also Useful for Fire-fighting.

The ends of Ventube sections and Ventube fittings are equipped with Braly patent ring couplings. All that is necessary to fasten two sections together is to squeeze either one of the rings to reduce its diameter and slip it through the other. Then pull back so that the inside ring rests snugly against the flange of the outer ring.

Suspension Accessories

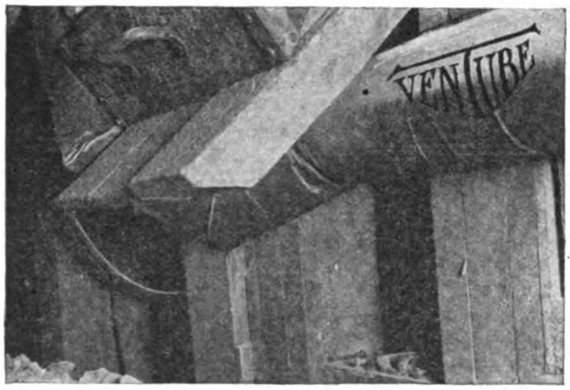
We recommend No. 8 B. & S. gauge galvanized iron wire hung close to the roof and tightly stretched, as a support. The Ventube is hung from this supporting wire by suspension hooks furnished for attachment in grommets placed in the suspension seam of the tubing. For hanging Ventube in shafts or raises a special suspension collar is fitted around the regular coupling. **A single workman can put up 2,000 feet of Ventube in one shift and can take it down as easily.**

DIMENSIONS OF VENTUBE AND FITTINGS IN INDIVIDUAL PACKAGES

	8"	12"	16"
Angles 45°	8½x 8½x2½	13 x13 x3½	17 x17 x3
Angles 90°	8½x 8½x2½	13 x13 x3½	17 x17 x3
Ys	10 x10 x5	14 x13½x5	18 x17½x5
Ts	10½x10 x5	15 x14 x5	19 x18 x5
Off Sets	8½x 8½x2½	13 x13 x3½	17 x17 x3
Fan Nipples	8½x 8½x1½	12½x12½x2	17 x17 x2
Fan Connections	8½x 8½x2	12½x12½x2	17 x17 x2½
Screens	9 x 9 x2¼	13½x13½x2½	17 x17 x2¼
Suspension collars	9 x 9 x2½	13 x13 x2½	17 x17 x2½
25 ft. lengths Ventube	15½x10 x3½	22 x14 x3	28 x17 x2½
50 ft. lengths Ventube	15½x11½x5	22 x15 x4½	29 x18 x4
100 ft. lengths Ventube	16 x14 x7	22 x16 x7	29 x19 x6
Reducers	13½x18 x2 (12"—8")	17 x17 x2 (16"—12")	17 x17 x2 (16"—8")

MINEFAB—For Covering Concentrating Tables

MINEFAB is a specially treated fabric of great tensile strength made permanently impervious and flexible by the thorough impregnation of both its surfaces with a non-deteriorating, waterproof, compound, highly resistant to chemical action and to abrasion. It is the only material ever made for the specific purpose of covering concentrating tables. Its capacity for withstanding the difficult conditions of metal recovery is the result of a careful analysis of these conditions and its adjustment to them by scientific manufacture.



VENTUBE Goes Anywhere. A Sharp Turn Under a Loading Chute.

MINEFAB is so pliable that the entire table can be covered by carrying it over the frame, under the feed box, over and under the waste edge, etc. This will preserve the entire deck as no moisture can seep through MINEFAB into the wood. Low temperatures will not cause MINEFAB to grow brittle or crack in handling or in use. **Its pliability is permanent.**

MINEFAB is highly resistant to the reactions of acid and alkaline solutions and to a cynaide solutions. This chemical stability and the resistance of its exceedingly tough surface to abrasion gives it a service life far greater than that of the materials it replaces.

MINEFAB is supplied 72 inches wide in rolls containing 30 lineal yards. The material is pure white on one side and black on the other, the side is used which gives the best contrast with the ore being worked. MINEFAB weighs 3 lbs. per lineal yard.

WEIGHTS OF VENTUBE AND FITTINGS IN INDIVIDUAL PACKAGES

	8"	12"	16"
Angles 45°	2 lbs.	2⅞ lbs.	3½ lbs.
Angles 90°	2⅛ lbs.	2 5/16 lbs.	4¼ lbs.
Ys	2 5/16 lbs.	5⅛ lbs.	7¼ lbs.
Ts	3 lbs.	4½ lbs.	6 lbs.
Off Sets	2 1/6 lbs.	3 1/16 lbs.	4 7/16 lbs.
Fan Nipples	2⅛ lbs.	3¼ lbs.	3⅞ lbs.
Fan Connections	4¾ lbs.	6⅛ lbs.	7½ lbs.
Screens	⅖ lbs.	⅗ lbs.	⅘ lbs.
Suspension collars	3/7 lbs.	1 lbs.	1¼ lbs.
25 ft. lengths Ventube	11⅛ lbs.	15⅝ lbs.	18 lbs.
50 ft. lengths Ventube	21½ lbs.	28⅝ lbs.	33⅜ lbs.
100 ft. lengths Ventube	40 lbs.	55 lbs.	65½ lbs.
Reducers	2⅞ lbs. (12"–8")	4⅜ lbs. (16"–12")	3⅝ lbs. (16"–8")

Add 20% to above weights when estimating the shipping weight of Ventube and Fittings in cases.

VENTUBE and MINEFAB Are Made By
E. I. DU PONT DE NEMOURS & CO., Fabrikoid Division, Newburgh, N. Y.

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SECTION XI

Mine Lighting

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Edison Storage Battery Co.
Grier Bros. Co., The
Justrite Manufacturing Co.
Shanklin Manufacturing Co.
Union Carbide Sales Co.
Wolf Safety Lamp Company of America, Inc.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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THE DEVELOPMENT OF MINE LIGHTS

Electric Lights

Electric lamps were placed on the market in 1902, but, on account of the objections common to all the earlier types, they were not favorably received.

In 1909 the Tungsten miniature lamps were first placed on the market in America for limited or special commercial uses. The efficiency or watts per candle, was about three to four times better than the carbon lamp.

In March, 1911, Thomas Edison became interested in the development of a practical miner's lamp and in May, 1912, the first lamps made by the Edison Storage Battery Company appeared, and concurrently the Wico lamp was introduced.

During the latter part of 1913 the Bureau of Mines, through H. H. Clark, became interested in the electric cap lamp, and after a personal tour of inspection and investigation took up the work with a view of standardizing its various features. Their chief concern was safety, thus making the lamp acceptable for general mine use. All available makes were studied and tested, and as a result a schedule of official tests was prepared, which was used in establishing a list of permissable safety lamps for use in mining. This step was the means of bringing home to the manufacturer the realization that the electric cap lamp was here to stay and created not a little competition to produce the best lamp possible.

Today we find the cap lamp comprising a non-spillable battery mechanically protected by an aluminum or steel case having the cover locked and arranged to be carried on a belt, a special twin flexible conductor conveying the current from the battery to the lamp on the cap, encased for a short distance at both ends by flexible steel armor, serving as an anchor and preventing sharp bending. The lamp consists of a parabolic reflector equipped with safety features, in which is mounted a tungsten lamp, the opening supporting a glass lens cushioned on gaskets held in place by a cap or spring, and provided with a hook to fit into the miner's cap.

When wearing the outfit a man can put himself in any position without restraint. It does not interfere with free motion of the body in any direction. He can use all tools and perform any desired work with as much freedom as when wearing the oil cap lamp.

Special combination charging stations are provided with facilities for charging, cleaning and filling both the electric lamps and the oil safety lamps.

The electric cap lamp has fully passed the development stage though improvements will doubtless continue, thus bringing it to a higher degree of perfection as the requirements are better understood and apprciated by the users.*

The electric hand lamp differs from the cap lamp only in detail. The battery and bulb are brought together into one unit and thus the cord is eliminated. As with the oil safety lamp it is carried by means of a bale and when at the working face can be hung on a post conveniently close to the workings. While the weight of the hand lamp is frequently cited as an objection it must be borne in mind that this weight is not continually carried as the case with the cap lamp.

The Acetylene Lamp

Acetylene gas was accidentally discovered in 1836 by Professor E. Davy, of Dublin; but not until 1892 was it produced at a commercially cheap rate. It was likewise accidentally discovered by H. Moissay, who, while conducting experiments with an electric furnace, noticed that the wall of the furnace, consisting of lime, fused into a liquid state at 3,000 degrees, Centigrade, and that a combination between it and the carbon of an electrode produced calcium carbide. T. L. Wilson, by accident also, while experimenting with an electric furnace, discovered a method which resulted in the manufacture of calcium carbide on a large scale.

Carbide lamps are too well known to require description. The following advantages over oil or candle light are claimed for them:

1. Produce no carbon monoxide.
2. Produce 1/10 the amount of carbon dioxide, and 1/13 the amount of water vapor that an equal light of candles would produce.
3. Consume only 1/5 as much oxygen.
4. Give a 4 to 6-candlepower light.
5. Cost less, being about eight cents for a 10-hour shift.

Their use has extended into nearly all the States. Some of the early objections to the use of carbide lamps are as here stated, but improvements made and a better understanding of the lamps have done much to weaken these.

First—The offensive odors from unconsumed carbide when the bottom is emptied in the mine.

Second—Gas escaping at the screw top.

Third—The scattering of fresh carbide on the damp floor, with the danger that the fumes from it may be ignited and cause injury to life and property.

Fourth—The possibility of fumes being given in the burning that are injurious to the sight and health.

Carbide Safety Lamp

In intelligent hands this lamp can be used successfully and an excellent light is afforded, which amply compensates the disadvantages

*For a very interesting account of the development of the electric cap lamp in America, see paper by J. T. Jennings, "Historical Development of the Miners' Electric Safety Cap Lamp," Proceedings Coal Mining Institute of America, 1916, and which has been drawn upon in this article.

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UNION CARBIDE SALES COMPANY

NEW YORK
Carbide and Carbon Bldg.
30 East 42nd St.

CHICAGO
Peoples Gas Bldg.

SAN FRANCISCO
Balfour Bldg.

WAREHOUSES IN 150 CITIES

"Miners Lamp" Union Carbide

Union Carbide For Mine Lamps

"MINERS' LAMP" UNION CARBIDE—Packed in 100-pound drums; 25-pound drums; 2-pound cans—24 cans to the case; 10-pound cans—6 cans to the case.

Manufactured by Union Carbide Company, the Original Producers of Commercial Calcium Carbide and today the world's largest makers of this product.

"MINERS' LAMP" is a size of UNION CARBIDE specially adapted for use in Miners' Carbide Lamps.

Because of its special selection, uniform high gas yield, special sizing and screening, and freedom from dust, "Miners' Lamp" Union Carbide is the most economical and satisfactory Carbide for use in Miners' Lamps.

"Miners' Lamp" Union Carbide will keep indefinitely if protected from air and moisture.

UNION CARBIDE—WORLD'S BEST QUALITY—HIGHEST GAS YIELD.

Union Carbide has for more than twenty-five years been recognized as the World's Standard for Quality in Carbide.

The use of Union Carbide results in greatest satisfaction and lowest cost, because:

It has the greatest gas content and is always uniform and dependable in quality.

Union Carbide is always the same—always highest grade and most carefully selected.

When using highest gas yielding Carbide, lamps and other apparatus require recharging less frequently.

Considerable time and labor is saved by the smaller number of chargings. The time saved can be applied to other duties.

The wear and tear on the lamps, or other apparatus, is lessened by reducing the number of rechargings.

There is a smaller quantity of residue to handle per unit of gas consumed, when highest gas yielding Carbide is used—another worth-while saving in time and labor.

When Carbide having the highest gas value is used, a saving is effected in the cost of transportation and handling charges in proportion to the amount of gas actually generated.

The correct uniform sizing and careful screening of UNION CARBIDE assists greatly in the economical, efficient and uninterrupted operation of lamps and generators.

Because of the faithfully sustained, always dependable quality of Union Carbide, it is easy for the Carbide user to estimate his Carbide requirements from time to time.

What Union Carbide Is Used For

In addition to being used by more than a million miners in cap lamps, hand lamps and other portable and stationary mine lighting equipment. Union Carbide, crushed to the several regular commercial sizes, is extensively used for the following purposes: The lighting of country buildings of all types and sizes; cooking; the oxy-acetylene process for welding and cutting all metals; contractors' torches and flare lights; lighthouses and bouys; train, locomotive, railroad signal and station lighting; motor vehicle lighting; life saving equipment; fire departments; physicians' lamps; scientific and laboratory purposes; searchlights; moving pictures; stereopticans; hunting and trapping, fishing, camping and boat lighting; gathering cotton and small fruits at night; night operation of tractors and other farm implements; steam boiler and other inspection work; and scores of other uses.

Our Blue and Gray Package

Union Carbide is always packed in distinctive Blue and Gray containers. The excellence of our package is in keeping with our aim to diligently protect the interests of users of our product in the matter of Carbide quality from the time it is packed at the Works until it is consumed by the user.

Union Carbide will keep for years in the original package without deterioration.

The Blue and Gray package is, therefore, a symbol denoting: best grade Carbide; highest gas value; uniform dependable quality, and purest gas.

Our Nation-wide Distributing System

For the convenience and economy of Carbide users we carry large stocks of Union Carbide in our own warehouses, at 150 convenient shipping points throughout the country.

Shipments are made the same day that orders are received.

Directory of Union Carbide Sales Company's Warehouses Appears on Opposite Page

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Union Carbide Sales Company's Remarkable Service and Distributing System

Shipments are made same day orders are received at our Warehouses located in the following cities. Orders can be addressed to Union Carbide Sales Company, at any one of the addresses given below.

ALABAMA
Birmingham.....12 So. 20th St.
Mobile.....16 So. Commerce St.
Montgomery.....15 Washington Ave.

ARIZONA
Phoenix.....42 So. Central Ave.

ARKANSAS
Ft. Smith.....123 So. 9th St.

CALIFORNIA
Fresno.....932 H. St.
Los Angeles.....639 Gibbon St.
Oakland.....(See San Francisco)
Sacramento.....217 O. St.
San Diego.....7th & J. Sts.
San Francisco.....
.....Balfour Bldg., 351 California St.

COLORADO
Denver.....19th & Waxee St.

CONNECTICUT
Hartford.....412 Trumbull St.

DISTRICT OF COLUMBIA
Washington.....
.....Maryland Ave. & 9th St., S. W.

FLORIDA
Jacksonville.....13 Cedar St.
Tampa.....805 Tampa St.

GEORGIA
Atlanta.....Haynes & Rhodes Sts.
Savannah.....
...Ogeechee Canal & Broughton Sts.

ILLINOIS
Chicago.....122 So. Michigan Boulevard
Danville.....511 Oak St.
Decatur.....133 W. William St.
E. St. Louis.....700 Broadway
Marion.....315 So. Granite St.
Monmouth.....124 E. Archer Ave.
Peoria.....100-110 Edmund St.
Quincy.....313 Delaware St.
Springfield.....1801 Washington St.
Streator.....501 E. Hickory St.

INDIANA
Evansville.....1601 Illinois St.
Ft. Wayne.....2216 Broadway
Indianapolis....110-112 So. Alabama St.
Terre Haute.....921 Wabash Ave.

IOWA
Davenport.....118 Harrison St.
Des Moines.....3rd & Elm Sts.
Dubuque.....8th & Washington Sts.
Ottumwa...207-9-11 So. Washington St.
Ft. Dodge.....Central Ave. & 16th St.
Sioux City.....925 4th St.
Waterloo.....1209 E. 4th St.

KANSAS
Pittsburgh.....109 W. 3rd St.
Salina.....154 No. 5th St.
Wichita.....Douglas & Sycamore Ave.

KENTUCKY
Beaver Creek.....P. O. Allen, Ky.
Central City.....306 Broad St.
Louisville.....126 E. Main St.
Middlesboro.....1701 Cumberland Ave.

LOUISIANA
New Orleans.....4124 Toulouse St.
Shreveport.....615 Market St.

MAINE
Portland.....11 Exchange St.

MARYLAND
Baltimore.....19 E. Lombard St.
Cumberland.....18 N. George St.
Salisbury.....Mill St. opp. Fulton Sta.

MASSACHUSETTS
Springfield.....Napier St.
Worcester.....15 Federal St.

MICHIGAN
Detroit.....5785 Greenwood Ave.
Grand Rapids..500 Shawmut Ave., N. W.
Hancock.....First Natl. Bank Bldg.
Iron Mountain.....513 Stephenson Ave.
Ironwood.....
Jackson.....172 So. Water St.
Muskegon.....301 W. Western Ave.
Saginaw.....1830-40 No. Michigan Ave.
Sault Ste Marie.....

MINNESOTA
Minneapolis.....334 N. 1st St.
Virginia.....413 Chestnut St.

MISSOURI
Kansas City.....1422 St. Louis Ave.
St. Joseph....6920 So. 6th St. Sta. "A"
St. Louis.....(See E. St. Louis, Ill.)

MISSISSIPPI
Vicksburg.....1312 Washington St.

NEBRASKA
Omaha.....1007-9-11 Jones St.

NEW JERSEY
Camden.....Front & Division Sts.
Newark.....251 Ridgewood Ave.

The 25 Pound Drum with Large Screw Top is an Economical, Convenient and Very Popular Package

NEW YORK
Albany.....108 3rd Ave.
Binghamton.....27 Jarvis St.
Brooklyn.....382 Metropolitan Ave.
Buffalo.....1336 Genesee St.
Geneva.....Exchange St. & R. R. Place
Hurleyville.....
Jamaica.....11 New York Ave.
Kingston.....O'Neil St. near Broadway
Niagara Falls.....
Poughkeepsie.....
Smith St. & N. Y., N. H. & H. Track
Utica.....135 Hotel St.
Watertown.....438 Court St.
Whitehall.....22-23 Main St.

NO. CAROLINA
Charlotte.....205 W. 1st St.
Raleigh.....
..204 W. Hargett St., P. O. Box 149
Wilmington.....
..Surry St., Bet. Castle & Queen Sts.
Wilson.....700 So. Goldsboro St.

NO. DAKOTA
Fargo.....5th St. & 2nd Ave., N.

OHIO
Athens.....Cor. Factory & Moore Sts
Canton.....618 Mulberry Road S. E.
Cincinnati.....67 Plum St.
Cleveland.....601 Citizens Bldg.
Columbus.....310 Dublin Ave.
Dayton.....812-828 E. 1st St.
Lima.....338 E. High St.
Mansfield.....40 W. 3rd St.
Steubenville.....324-343 No. 7th St.
Toledo.....414 S. Erie St.
Youngstown.....Jones & Brittain Sts.
Zanesville.....Main & 2nd Sts.

OKLAHOMA
McAllister.....8 No. Main St.
Oklahoma City.....4 W. Park Place
Tulsa.....1-11 No. Boulder St.

OREGON
Portland.....15th & Hoyt Sts.

PENNSYLVANIA
Beaver.....262 East End Ave.
DuBois.....Weber Ave. & Franklin St.
E. Queensburg.....Clark & George St.
Erie.....1426 Chestnut St.
Harrisburg.....25 S. 10th St.
Johnstown.....
.....Messenger St. & B. & O. R. R.
Philadelphia.....2nd St. & Fishers Ave.
Pittsburgh.....
...1202 Chamber of Commerce Bldg.
Pottsville.....R. R. & Sanderson St.
Scranton.....Penn Ave. & Vine St.
Shamokin.....5th & Walnut Sts.
Williamsport.....Canal & Court Sts.
Wilkes-Barre....150 E. Northampton St.

SO. CAROLINA
Charleston.....3 Liberty St.

TENNESSEE
Chattanooga.....312 Pound Bldg.
Knoxville.....426 W. Depot Ave.
Memphis.....671 So. Main St.
Nashville.....105-7-9 Broadway

TEXAS
Dallas.....1008 Canton St.
El Paso.....First & Kansas Sts.
Houston.....
..Baker & Cedar Sts., P. O. Box 1214
San Antonio.....115 So. Medina St.
Waco.....13th & Mary Sts.

UTAH
Salt Lake City..108 W. Second South St.

VIRGINIA
Lynchburg.....1324 Commerce St.
Norfolk....Natl. Bank of Commerce Bldg., 300 Main St.
Richmond.....1709 E. Cary St.

WEST VIRGINIA
Bluefield.....195 Roanoke St.
Charleston...Broad St. & K. & M. R. R.
Elkins.....Railroad Ave. & 1st St.
Fairmont.....Auburn St.
Huntington.....7th Ave. cor. 8th St.
Mount Hope.....P. O. Box No. 416
Morgantown.....178 Clay St.
Mullens.....P. O. Box 55
Wheeling.....43rd & McColloch Sts.
Williamson.....P. O. Drawer L.

WASHINGTON
Seattle.....304 Railroad Ave. So.
Spokane.....162 So. Post St.

WISCONSIN
La Crosse.....Front & King Sts.
Madison.....513-19 Williamson St.
Milwaukee.....120-134 Jefferson St.

UNION CARBIDE IS EASILY OBTAINABLE EVERYWHERE

Requests for Information and Special Correspondence Should be Addressed to our New York, Chicago or San Francisco Offices

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THE GRIER BROTHERS COMPANY

1411-1417 Brighton Road, PITTSBURGH, PA.

Factory: PITTSBURGH, PA. Western Branch: HANCOCK, MICH.

Manufacturers of

Grier J. & T. Carbide Lamps

The Miners' Delight

Products

Carbide Lamps for Miners; Carbide Flasks—Tips and other repair parts; Miner's Dinner Pails, Powder Cans and other miner's equipment.

J. & T. Tip Cleaner

The J. & T. Tip cleaner with which Grier Lamps are now equipped is a recent invention, and thoroughly covered by patents. The cleaner is always with the lamp ready for instant use. The tip can be cleaned as often as necessary **without extinguishing the light.** It will save the miner both time and money. The cost added to the price of the lamp is very little compared to the advantages to be derived.

Cut Showing How J. & T. Cleaners Are Installed in Grier Lamps

Construction—The device is so simple that there is nothing to get out of order from corrosion or otherwise.

A small wire of special composition works inside of the lamp, being housed in a brass tube and attached to a push button. A slight pressure on the button on outside of lamp injects the wire into the gas orifice in the burner and forces out any dirt or other matter lodged in the burner.

The diameter of the cleaning wire is slightly less than the diameter of the gas opening in the burner, so that when the wire is projected into the opening the light will not be extinguished.

It is not necessary to remove the lamp from the cap.

All lamps tested before leaving our factory. Lamp equipped with Grier "Loc-on" reflectors and brass, lava insulated tips. All parts are easily replaced. Lamps made with 2¼", 2½" and 3" reflectors. Not a better made lamp on the market.

Round Hook Coal Miner's Lamp

Flat Hook Metal Miner's Lamp

Inspector's Lamp—Large Carbide Bottom

WRITE FOR CATALOG

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JUSTRITE MANUFACTURING CO.

2061-2081 Southport Ave., CHICAGO, U.S.A.

Justrite TRADE MARK
Built to Give Service

Manufacturers of

Carbide Miner's Lamps

For All Mining Purposes

Products

Miner's Lamps—all types—in brass, steel and aluminum.

Miner's Caps—Carbide Flasks—Burner Tips—and all necessary supply parts.

Sanitary Pails and Oily Waste Cans.

The models illustrated on this page are the most desirable for metal miners, and are known as "Metal Mine Lamps."

All lamps except "Little Giant" and "Uncle Sam" are equipped with self-lighter attachment. "Justrite" Lamps are constructed on scientific principles—only the very best material and workmanship being used. Every lamp is guaranteed.

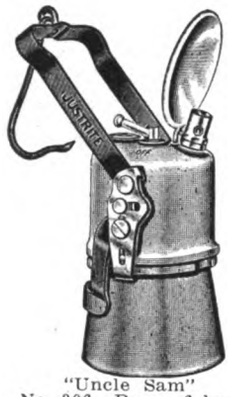
If interested in other models, consult our general catalog.

LARGE TYPE LAMPS

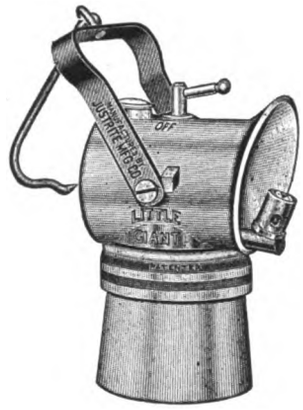
Cap Lamp
No. 407—Wire Feed
No. 707—Polygon Feed
Burns 2½ hrs.
Brass or Nickel

Superintendent's Lamp
No. 302—Burns 5 hrs.
No. 95—Burns 4 hrs.
Brass Nickelplated

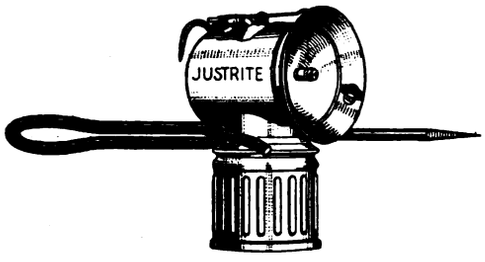
"Arizona Special"
No. 83—Burns 5 hrs.
Brass



"Uncle Sam"
No. 306—Burns 6 hrs.
No. 308—Burns 8 hrs.
Aluminum



"Little Giant"
No. 110—Burns 6 hrs.
Aluminum



Candle Stick Lamp
No. 103—Brass. Burns 4½ Hours.

The New "Acme" Steel Lamps
Rustproof Finish—Half Shift Size
Wind and Water-proof

"A Strong and Rugged Steel Lamp."

The "Acme" Lamp is so constructed that it will give the miner a dependable and efficient light at the most economical cost.

Note particularly the reflector, which fits snugly into the reflector brace, and is held in a permanent and rigid position by the knurled nut—not easily bent, broken or lost. Also equipped with No. 171 Flame Protector.

This lamp has been tried by many of the large mining companies, and has given most excellent service.

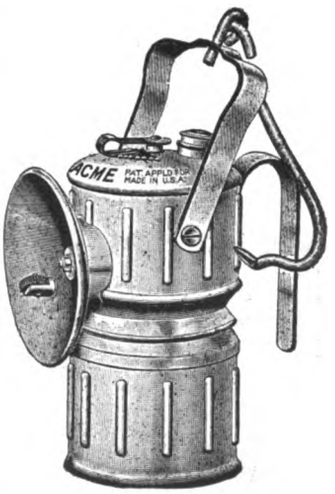
Consistent with the cost of this lamp, it is the best value of any steel lamp on the market.

No. 56—With Folding Handle
Steel

SPECIFICATIONS

Burning Capacity—5 to 6 hrs.
Candle Power—18 C. P.
Weight—15¼ ounces.
Charge (¼" Carbide) 5 ozs.
Height of Lamp—5½ inches.
Height to top of bail—7¾ in.
Diameter Bottom—2⅞ inches.
Diameter Reflector—3 inches.

No. 171—Flame Protector



No. 50—With Bail and Hook
Steel

WRITE FOR CATALOG

WORLD'S LARGEST MANUFACTURERS OF CARBIDE MINER'S LAMPS

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SHANKLIN MANUFACTURING CO.

2725-27-29 S. Eleventh St., SPRINGFIELD, ILL.

Miners' Carbide Lamps and Supplies

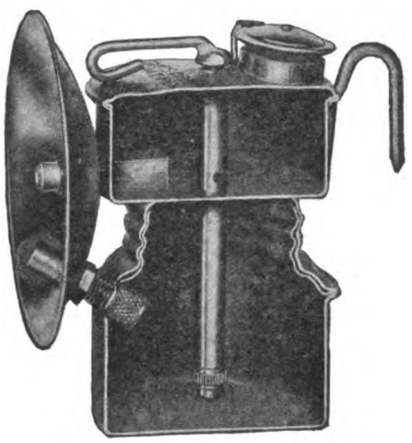
Products

Miners' Carbide Lamps; Carbide Lamp Supplies.

Shanklin's Carbide Lamps

These lamps are made in a wide variety of styles, as described below.

The outstanding feature of all lamps is the Guy Patented Water Dropper, which was perfected several years ago by Mr. Frank Guy, a practical miner, and we have used it for nine years in our lamps, during which time it has proved to be a most accurate and thorough device for feeding water to our Carbide Lamps.



Guy's Patented Water Dropper

A feature of the Guy Water Dropper is the Valve Cleaner, which is a knurled thimble put on the dropper between the button and the end of the dropper tube. If dirty water is used and the dropper becomes clogged, a few turns of the valve cleaner with the fingers will open it up.

No. 22 S. L. Lamp

Has 2¾" polished reflector, fastened to lamp with lock-nut screwed on burner tube. Reflector is strongly reinforced on back to protect it from accidents. Intended for use in rooms or entries with high roofs.

Brass lamp only, retail price $1.00.

No. 22 S. L. Corrugated or Hex. Bottom; Flat Hook or Round Hook and Brace.

No. 22 Lamp, same as No. 22 S. L., without self-lighter added to reflector. Retail price $1.00.

No. 220 S. L. Lamp, same as No. 22 S. L., but nickel plated. Retail price $1.25.

No. 23 S. L. Corrugated or Hex. Bottom; Flat Hook or Round Hook and Brace.

No. 23 S.L. Lamp

Has large, deep, highly polished 3-inch reflector, fastened to lamp by lock-nut screwed to burner tube. Reflector strongly reinforced on back to protect it from injury.

Intended for inspectors and workmen needing an extra large light. Throws a bright spot of light 50 feet.

Brass Lamp only. Retail price $1.15.

No. 23 Lamp same as No. 23 S. L., except without lighter. Retail price $1.00.

No. 230 S. L. Lamp is same as No. 23 S. L., but nickelplated. Retail price $1.40.

No. 10 S. L. Superintendent's Lamp.

No. 10 S. L. Lamp

Superintendent's hand lamp. Can be furnished with any of our reflectors, but is usually equipped with the No. 23 S. L. reflector.

Has 50 per cent. more capacity than our regular lamp and will burn 4 hours. Has large hook and large folding handles.

Can be worn on the cap.

Brass lamp only; retail price $1.50.

No. 100 S. L. Lamp. Same as No. 10 S. L., but nickelplated. Retail price $1.75.

No. 6 S. L. Lamp

Has an extra large, deep 2¾-inch reflector highly polished. Reflector fastened to lamp by lock nut in usual manner. Reflector strongly reinforced on back to prevent injury. Intended for superintendents or inspectors needing an extra large, strong light. Throws a bright spot of light 50 feet. Lamp is same size as regular cap lamp and equipped with handles. Can be worn either on the cap or carried in the hand.

Retail price $1.35.

No. 60 S. L. Lamp. Same as No. 6 S. L., but nickelplated. Retail price $1.60.

No. 6 S. L. Lamp

No. 4 Candlestick

Slips on over bottom of lamp. Much stronger and better than a stick that clamps around the screw cap. Does away with the screw cap spreading and making a gas leak around the rubber gasket. Fits our cap lamps and four-hour lamps.

Retail price 30 cents each.

Candlestick

No. 6 Candlestick

Same as No. 4, but made to fit our half-shift lamps. Retail price 35 cents each.

Supply Kit

Contains an assortment of lamp supplies most frequently called for by the miner; also, the repair parts most likely to become lost or worn out, and which require replacement.

Conveniently arranged in a strong, durable cardboard box with hinged cover.

No. 1—$8.00; No. 2—$4.50.

Supply Kit

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Wolf Safety Lamp Company of America, Inc.

220-224 Taaffe Place, BROOKLYN, N. Y.

Miners' Carbide Lamps

Products Made in U. S. A.

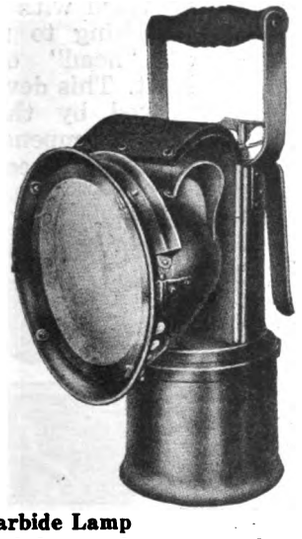
Miners' Carbide Lamps for hand, cap, trip and general utility purposes. Miners' Safety Lamps burning naphtha, vegetable oil and carbide. Tools and Accessories for all types of lamps. Newton Oiling Device for mine car wheels.

ALL WOLF LAMPS ARE GUARANTEED TO GIVE SATISFACTION and are the strongest and best mining lamps made. No screw threads used on our lamps, which is one of the weakest points on Carbide lamps.

Lamps are made in all metals and different sizes.

No. 905a Carbide Hand Lamp

This lamp is finished in steel tinned, with a sharp or plain hook and very similar to the No. 856, except it is equipped with a parabolic reflector protecting flame against dripping water. The burning time is 5 to 6 hours. Weight 1¾ lbs. Height 8½ inches.



No. 871 Carbide Lamp

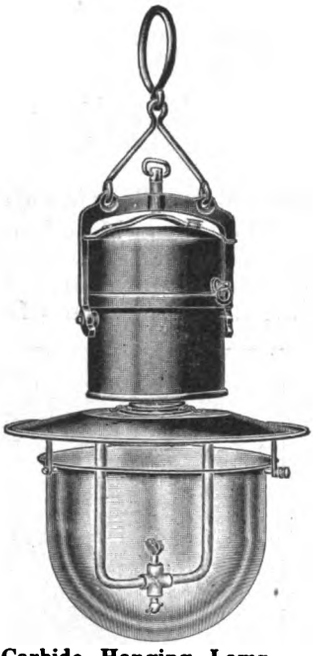
An ideal lamp where an enclosed flame is required. Lamp steel tinned. Reflector hood in brass with aluminum insert. Weight 3¼ lbs. Height 11 inches.

Carbide Lamp No. 856 Trip Light

The attachment that fastens this lamp to the trip is constructed in such a way that no jars can affect the lamp. The lamp, however, can be removed at once if required as trouble light.

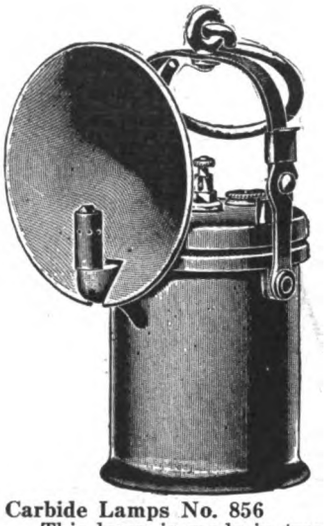
Carbide Table Lamp No. 91

Where gas or electricity is not available this table lamp will make any large room as light as day. It is handsomely finished in nickel-plate, has a beautiful opaque glass shade.



Carbide Hanging Lamp No. 750a

With glass dome and a powerful burner, competing with an electric arc light. Will easily light up a space 20x20. Burns 12-14 hours with 60 c. p. Weight 14 lbs.



Carbide Lamps No. 856

This lamp is made in two sizes: smaller one has a burning time of 5 to 6 hrs.; larger size burns 7 to 8 hrs. Either of these lamps may be equipped with a reflector hood (as shown above) and both have the automatic non-adjustable water-feed.

Made in brass and steel, heavily tinned.

Write for complete catalog and descriptive circulars describing our many other types of Carbide lamps and lanterns. We make a lamp for every purpose.

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Edison Storage Battery Company

Factory and Main Office

316 LAKESIDE AVENUE, ORANGE, N. J.

Manufacturers of the

Edison Electric Safety Mine Lamp

A PRODUCT OF THE EDISON LABORATORIES

Distributors in

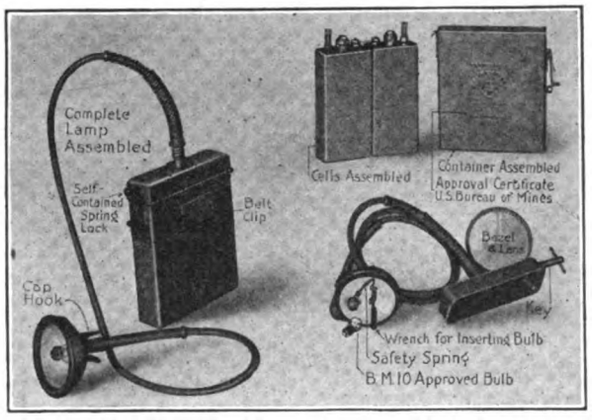
NEW YORK, ATLANTA, NEW ORLEANS, BOSTON, CLEVELAND, DETROIT, PHILADELPHIA, PITTSBURGH, WASHINGTON, CHICAGO, ST. LOUIS, MONTREAL, SAN FRANCISCO, SEATTLE, LOS ANGELES

General Distributors

Mine Safety Appliances Co., Pittsburgh, Pa.

The Edison Electric Safety Mine Lamp

The Edison Mine Lamp is a **permissible** portable Electric Mine Lamp. It is the first to be approved by the Bureau of Mines for Safety, Practicability, Efficiency and General Durability in Mine Service.



Unassembled View Edison Mine Lamp

Standard in over 1,000 mines, over 175,000 in use in Metal and Coal Mines of the United States.

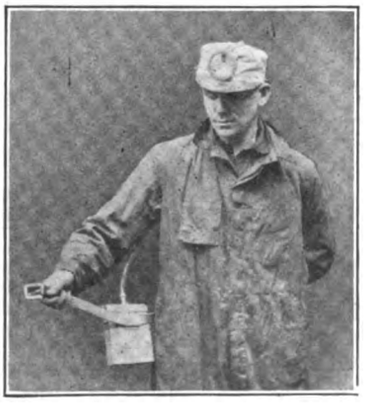
Older installations show uninterrupted service over five years.

Burns 12 hours without recharge.

Fire Protection for your valuable operation.

Method of Attaching

The miner straps the battery case to his back by an ordinary belt. The lamp is attached to the



Method of Attaching

leather support in his cap, leaving his arms entirely free of lamp, cord and battery case.

Described in Bulletin No. 300.

See Page 342 for details of the Edison Battery.

Edison Shot-Firing Battery. Showing how special cover for shot-firing is attached to regular Edison Mine Lamp.

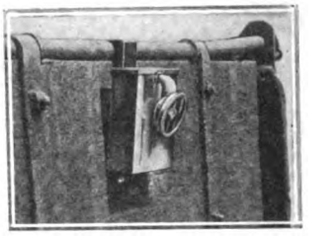
The Edison Electric Shot-Firing Battery

Showing cover for M-8 Mine Lamp Battery arranged for shot-firing. Shot-firing cable is attached to a key furnished with cover. Key is then inserted in receptacle on cover, and detonation accomplished by pressing key into contact. Cover is furnished with or without fittings for lamp attachment.

It is simple, lightweight, strong and durable. One charge of the battery is capable of firing a great many shots.

Edison Electric Safety Trip Lamp

Consists of M-8 (Mine Lamp) Battery in steel case with special cover and lens. The case is provided with hook for attaching to mine car as "head" or "tail" light. This device is approved by the Workmen's Compensation Insurance Inspectors.



Edison Trip Lamp—Hooks Over Either End of the Car

Edison Electric Safety Hand Lamp

Illustration shows arrangement of Edison Safety Mine Lamp as a hand lamp. This consists of a standard M-8 Battery in steel case with special cover. The lamp is attached directly to cover and the cover provided with bails for attaching leather handle. Largely used as Inspector's, Official's and Visitor's lamp.

Electric Safety Hand Lamp

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SECTION XII

Open Cut and Quarrying

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Allis-Chalmers Mfg. Co.
Armstrong Mfg. Co.
Industrial Works
Jordan, O. F. Company
Kleinhans, H. Co.
Link-Belt Company
Marion Steam Shovel Co., The
McLanahan-Stone Machine Co.
Sanderson-Cyclone Drill Co., The
Taylor-Wharton Iron & Steel Co.
Worthington Pump and Machinery Corporation

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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UNDESIRABLE DIVERSITY IN NON-METALLIC MINERAL PRODUCTS*

During the war period production, greater and more intense production, was the key-note of commercial activity, and other manufacturing problems were submerged beneath this dominating impulse. Industry has suffered from the effects of such unbalanced development and an effort is now being made to rectify the errors of the past.

The present business depression has permitted operators to direct their attention toward phases of industry other than volume of output, and one of the notable results is the tendency to analyze and seek a remedy for the present undesirable industrial condition. Many operators have concluded that a cure may be effected in large part by correcting defects in the producing industries themselves. Thus a period of commercial housecleaning has set in, the chief object of which is to eliminate non-essentials both in products and equipment, and to reduce production cost through simplification of processes. This movement is quite pronounced in the mineral product industries. For example, the statement has been made that a Boston firm manufacturing pipe-fittings has taken advantage of the present period of industrial inactivity to make a careful analysis of its business, with the startling result that of the 17,000 products listed in its catalog only 650 have been bringing any profit to the firm. Obviously an effort will be made to reduce or eliminate the manufacture of as many as possible of the unprofitable products.

It may appear at first sight that this is a manufacturing rather than a mining problem, but it has a special significance in the non-metallic mining industries, where many of the final or intermediate products are manufactured at the mine or quarry, as such processes of manufacture must be considered as an integral part of mining in its broader sense.

In the movement toward simplicity in products it is evident that two important processes are involved. They may be briefly termed elimination, and standardization. To determine what products may properly be eliminated a careful statistical survey is necessary, a survey covering production and demand for each individual product over a series of years. When a definite conclusion is thus reached the next step is to arrive at an agreement between consumers and producers as to the extent that elimination of superfluous products may be accomplished. The chief requirement, therefore, is a mutual agreement based on facts deduced from statistical data.

The second process, that of standardization, is much more complex. Standards may be established only when a very thorough knowledge has been gained of the physical and chemical properties of the products, and the requirements of consumers. The activities of the Bureau of Standards are largely directed toward such determinations. A proper standardization of products is really essential to any intelligent effort toward reduction in the number of varieties of products.

The movement in the non-metallics toward elimination of superfluous varieties, and better standardization of essential products is gaining in force. The notable accomplishment of a conference held at the Department of Commerce in Washington, D. C., November 15, 1921, will undoubtedly add impetus to the movement.

Paving Brick

Paving brick manufacturers, together with highway engineers, representatives of certain engineering societies, and government bureaus, agreed unanimously that of the 66 styles of paving brick then on the market 11 were to be regarded as essential and 55 as superfluous. Steps were immediately taken to reduce the output as far as possible of all but the 11 standard types.

Slate

Evidence of a similar tendency is to be noted in the slate industry. It is customary for manufacturers of structural slate to prepare it in sizes specified by builders and architects. Thus the material cannot be manufactured in advance. This results in irregular activity of mills, delays in filling orders, and may force manufacturers to use raw materials that might be better adapted for products than those called for in the orders. To improve this condition the Structural Slate Company of Pen Argyl, Pa., through the Structural Service Bureau of Philadelphia, has issued a series of pamphlets giving complete specifications of structural slate for various purposes. Architects find it so much easier to order slate from these sheets that, in preparing plans for new structures, standard sizes are specified. There is evidence, therefore, of a definite movement toward elimination of odd sizes. The new specifications have been in effect so short a time that results cannot yet be measured, but it would appear that slate producers will shortly be enabled to build up a reserve stock of standard sizes. Such a reserve will be advantageous both in marketing and in manufacturing.

Slate switchboards are likewise usually manufactured after the order has been received. The most serious objection to the filling of orders directly from the quarry is that, according to tests recently made on Pennsylvania slate, freshly quarried slabs have only about half the resistance in ohms of the same slabs after drying out for three months. One Chicago manufacturer claims that 80 per cent. of all switchboards are of standard sizes, and he keeps such sizes in stock. The facility with which orders may be filled from stock, and the improved quality of seasoned switchboards, will undoubtedly influence electrical companies toward a more uniform standardization in size. Simplicity could be further attained by the elimina-

*By Oliver Bowles. Presented at February, 1922, meeting of A. I. M. & M. E. Published by permission of the Director of the Bureau of Mines.

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tion of minor irregularities in style, as for example in the beveled edges. Some companies now demand a bevel one-half inch wide, and others one-fourth inch wide. It would seem that uniformity in this detail could be easily adjusted.

Structural Materials

Similar tendencies may be noted in the structural block, sand, gravel and crushed stone industries. Limestone quarrymen have found it advantageous to establish a standard size 8 x 4 x 4 feet, for mill blocks, and large piles of such blocks are stored for seasoning before shipment to stonecutters. Concrete blocks, artificial stone, terra cotta, and similar types of molded building blocks are gradually being standardized in size and shape.

Sand, Gravel and Crushed Stone

Producers of sand, gravel and crushed stone have been greatly handicapped by the varied requirements of consumers. Construction engineers differ widely in their views as to the sizes of crushed stone, sand and gravel best suited for their requirements, and thus demands have arisen for a multiplicity of sizes, necessitating costly and complex screening equipment. The producer may be even obliged to purchase new screens simply to fill special individual orders. For the past two years various organizations have been striving to establish standard screens, and to eliminate all unnecessary sizes. A notable step in this direction is the preparation of a set of tentative specifications issued in 1920 by the American Society for Testing Materials working in co-operation with the Bureau of Public Roads. These specifications call for screen openings of a limited number of standard sizes. Thus users of crushed stone, sand and gravel are encouraged to confine their orders as far as possible to standard sizes, with a consequent tendency toward simplification of equipment and reduced production cost.

In many of the non-metallic mineral industries there is need of better standardization and greater simplicity in products, but little interest has yet been manifested in accomplishing this result. Some of the more outstanding examples of undesirable complexities, with no evident prospect of improvement, are discussed in the following paragraphs.

Granite

Granite paving blocks are manufactured in a great variety of sizes. Eleven varieties, sold under trade names, were reported to the United States Geological Survey in 1917, and many other varieties were sold by sizes only. The State of Maine reported 7 different sizes, New York 7, Massachusetts 10, and other states a varying number. Undoubtely some latitude should be allowed in paving block dimensions, particularly in length, but too great a complexity is involved both in manufacturing and in street construction, where every state or city writes its specifications without regard to the requirement of other localities.

Feldspar

Feldspar is standardized neither as to grain sizes nor purity. No. 1 spar is variously defined as dental spar only, as pure feldspar of any kind, or as a mixture of feldspar with a small percentage of quartz. Some No. 2 spar is limited to 5 per cent. quartz, while other consumers classify as No. 2 a spar which contains as high as 25 per cent. quartz. Specifications may call for fixed percentages of soda and potash, or such requirements may be omitted. Ground feldspar is commonly reduced to 140 mesh, but there is no standard requirement in size.

Mineral Fillers

The broad field of mineral fillers is sadly lacking in standardization. Many users of filler materials have very indefinite knowledge of their requirements either in color, grain size, grain shape or chemical composition. The standardization of fillers is practically an untouched field, and such standardization accomplished through a comprehensive study of the subject would not only promote better manufacturing processes but would be of material benefit to producers. It is claimed by one producer that the cost of purchasing special screens to satisfy the requirements for odd sizes of his finished product for one customer destroys most of the profit obtained from grinding roofing grade talc.

Mica

The classification of mica is very confusing, for standards differ not only in different countries but in different parts of our own country. The most widely known domestic standard includes punch, circle and rectangles of various sizes such as 1½ x 2; 2 x 2; 2 x 3; 3 x 3, and up to 8 x 10 inches and larger. Canadian phlogopite is graded in sizes of rectangles that differ from most of the United States standard sizes, as for example 1 x 1; 1 x 2; 1 x 3; 2 x 3; 2 x 4, etc. India mica is widely used in the United States, and it is classified, not on the basis of the sizes of rectangles obtainable, but on the basis of the area of good mica in the sheet, for which 10 arbitrary grades have been established.

In quality domestic mica is classed as clear, slightly spotted or stained, and heavily spotted or stained. No definite boundaries have been fixed for these grades. Mica sold as "clear" is commonly spotted, and this has prejudiced users against domestic mica. Looseness in classification is detrimental to the development of new deposits, for the producer, unskilled in classification, is largely at the mercy of the broker who may so degrade the product that the owner of the deposit may abandon it as unprofitable. A better standardization both as to quality and size would be of very great benefit to the mica industry.

Conclusion

It is apparent, therefore, that some of the non-metallic mineral industries have already awakened to a realization of the necessity for better standardization of products, and that a growing tendency may be noted toward greater simplicity and uniformity. In other industries the need is just as great, but the necessity for improvement is either unrecognized or its recognition is still dormant. It is well to emphasize, however, that in a number of industries a great deal of study and experimentation must be done before a proper basis for standardization may be attained.

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LOADING DATA

Hand Work

One man will load 2 to 20 cu. yd. of rock (place measurement) in 10 hrs., depending mainly on size of pieces and height to be lifted. On the Chicago Drainage Canal the average per man in 10 hrs. was about 7 cu. yds. loaded into dump cars. Sledging took 14% of the time. Average per man loaded into low cable way skips, 10 cu. yds. Crushed stone can be shoveled from smooth boards or steel sheets at the rate of 13 cu. yds. solid measure (22 cu. yds. loose) in 10 hrs.; in shoveling from the ground or hopper bottom cars, 1 man will do only 7 to 8 cu. yds. solid measure (12 to 14 cu. yds. loose).

OUTPUT OF STEAM SHOVELS, LOADING BLASTED ROCK (TEN HOURS' WORK)

Material	Iron ore				Limestone			Slate limestone	Porphyry, granite	Porphyry	Sandstone
Work	In bank		Stock pile		Quarry	R. R. cut		R.R.	R.R.	R.R.	Canal
Condition	Good	Fair	Good	Fair	Fair	Low	Face	Good	Hard	Hard	Bad Drilling
No. of shovels	1	1	Av. of 5	1	Av. of 2	1	1	Av. of 2	Av. of 2	1	1
Size, tons	70	95	70	90	95	65	70	70	70	65	70
Dipper, cu. yds.	2.5	2.5	2.5	2.5	2.4	...	...	2.5	2.5	2.5	2.5
Coal, tons	1.75	3	2.35	4.5	3.5	2.8	2.3	2.8	2.2	2.2	3
Oil, gal	1.4	3.25	1.45	8.5	...	...	...	...	...	...	5
Water, gal	3000	5000	3500	7700	...	...	...	...	...	...	4500
Cu. yds. loaded	892	1350	1251	2728	917	358	205	1126	799	447	470

Steam Shovel Work

In the soft iron ore of the Mesabi range, under fair conditions, a steam shovel easily loads 250 cu. yds. per hour; but, in poorly drilled and blasted rock, broken in large pieces, a shovel may do as little as 17 cu. yds. per hr.

LIFTING CAPACITIES IN POUNDS OF ROAD WHEEL, CRAWLING TREAD AND STANDARD GAUGE LOCOMOTIVE CRANES

The following loads can be safely handled without the use of outriggers or other stabilizing devices.

Radius, ft.	7-ton	12-ton	18-ton	22-ton	25-ton	30-ton	40-ton	50 and 60-ton
10	18,000	30,700						
11	15,800	27,000	40,500					
12	14,000	24,000	36,000	44,000	50,000	60,000	66,000	70,000
14	11,400	19,700	29,400	35,900	40,800	49,000	53,900	57,300
15	10,400	17,900	26,800	32,800	37,200	44,800	49,400	52,400
17	8,900	15,300	22,800	27,900	31,700	38,100	42,000	44,700
20	7,200	12,400	18,500	21,600	25,700	31,000	34,200	36,400
25	5,500	9,700	13,900	17,000	19,300	23,400	25,800	27,600
30	4,400	7,700	11,500	13,400	15,200	18,500	20,500	21,900
35	3,500	6,300	9,400	11,600	12,400	15,200	16,700	18,000
40	2,900	5,200	7,900	10,000	11,000	13,500	14,000	15,100
45	2,300	4,400	6,700	8,600	9,400	11,500	12,800	13,400
50	1,900	3,700	5,600	7,100	8,200	10,100	11,200	11,600
55	1,500	3,100	4,700	6,100	7,000	8,700	9,600	10,000
60	1,200	2,600	3,900	5,200	6,000	7,500	8,300	8,700

With outriggers extended the capacities of 25-ton and smaller sizes of rail cranes are increased 50%; the capacities of the 30-ton and 50-ton cranes are doubled; the capacities of the 40-ton crane are the same as for the 30-ton crane; and the capacities of the 60-ton crane are two and a half times as great as given in the above table for the 30-ton crane.

Lifting capacities of standard gauge locomotive cranes are calculated according to the established standard of the Locomotive Crane Manufacturers' Association.

BLAST HOLE DRILLING AND QUARRYING DATA

Are extensively used for deep holes for blasting in the softer rocks. Advantages, as compared with machine drills: Any depth can be drilled, to the possible limit of blasting; no stripping of the overlying earth is necessary; holes in high faces are drilled to full-depth, instead of working in benches; the large-diameter holes permit larger charges, hence wider spacing of fewer holes, and consequent saving of time, and smaller consumption of fuel for power. To offset these points, machine drills possess the advantages of portability, and speed of drilling.

SPEED OF BLAST-HOLE DRILLING WITH CHURN OR CABLE DRILL

Kind of material	Ft per hr	Diam hole, in	Depth, ft	Machine	Remarks
Clay, soapstone	10	5⅝	18	....	Railroad work
Limestone	9	5½	30	Cyclone	Cement quarry
Limestone	8	5	34	Cyclone	Lime, crushed-rock quarry
Shale	6	5⅝	20	Cable drill	....
Overburden, porphyry ore	5.7	.....	55	Keystone	Open pit mining
Limestone	5.5	5⅝	.....	Keystone	Crushed stone
Hard, seamy basaltic rock	5.2	3	23	Cyclone	....
Soil, gravel	5.2	2½	23	Cyclone	....
Brown sandstone	5.0	3	24	Cyclone	....
Brown sandstone	5.0	5½	50	....	Crushed stone
Shale	4.8	5⅝	75	Star	....
Hard, seamy limestone	4.7	5	22–30	Loomis	....
Half earth, half slate	4.4	.....	12	Keystone	Aqueduct
Limestone	4.0	.....	50	Keystone	Lime quarry
Limestone	3.9	5⅝	40–45	....	Quarry
Copper ore, porphyry	3.5	6½	60	Keystone	Mining
Shale	2–8	4½–6	20–80	Star	....
Shale	1.8	5⅝	18	....	....
Copper ore	1.5–2.5	6	30–35	Star	Mining
Limestone	1.5	5	45–85	Star	Cement quarry
Limestone, sandstone	1.0	5⅝	20	Cable drill	....
Hard limestone	0.5–1	5⅝	18	....	....

RATE OF CUTTING WITH CHANNELERS (SULLIVAN)

Location	Kind of Rock	Sq. Ft. Cut	Time
Quarry Work			
Phillipsburg, Que.	Marble	63	10 hrs.
W. Rutland, Vt.	Marble	100	10 hrs.
		2509	Average month
Tennessee	Marble	80	Average day
Vermont	Marble	219	High day
Georgia	Marble	200	Average day
Tennessee	Marble	150	Good day
Brandon, Vt.	Hard marble	1485	Average month
Brandon, Vt.	Hard marble	1677	Average month
Bloomington, Ill.	Limestone	6000	10 days
Batesville, Ark.	Hard limestone	130	Average day
Carthage, Mo.	Hard limestone	137.5	Average day
Amherst, O.	Sandstone	225	Day
Florida, Keys	Coral rock	750	Average 10 hrs.
Pennsylvania	Slate	60	Average day
Vermont	Slate	75	Average day
Virginia	Soft soapstone	200	Average day
Virginia	Soft soapstone	262	Average day
Contract Work			
Lockport, Ill.	Limestone	210	Average 10 hrs.
Lockport, Ill.	Limestone	382	High 10 hrs.
Sault Ste. Marie	Hard limestone	75–100	Average day
Keokuk, Ia.	Hard limestone	80	10 hrs.
Sault Ste. Marie	Sandstone	70–80	8 hrs.
Sault Ste. Marie	Tough Sandstone	60–75	8 hrs.
New York City	Gneiss	60–75	8 hrs.
Panama Canal	Med. broken rock	120	8 hrs.

Courtesy Sullivan Machinery Co.

All material in this section unless otherwise noted from Peele's Mining Engineers' Hand Book (Wiley & Sons).

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Allis-Chalmers Manufacturing Company

MILWAUKEE, WISCONSIN

For Branch Offices and Other Products, See Page 168

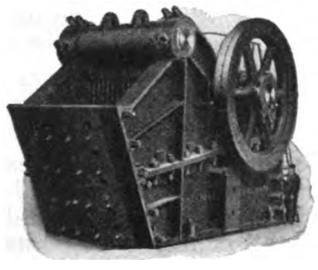
Crushing and Grinding Machinery

Products

Crushers; Pan and Bucket Elevators; Skips; Hoists; Kilns; Coolers; Dryers; Revolving and Shaking Screens, Compeb, Ballpeb, Rod and Tube Mills.

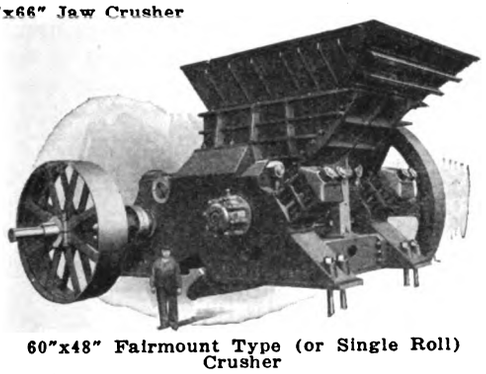
The company has developed in all sizes the latest in gyratory crushers, the Gates Style "N" Machine, which is the result of the accumulated experience of the Engineers and Designers of the Gates Iron Works and the Allis-Chalmers Mfg. Co. Every letter between "A" and "N" represents some form of a Gyratory Crusher. Only a few of the types up to the style "D" and "K" have been manufactured in large quantities, but in most of the types several experimental machines have been built and in the style "N" Crusher is embodied the knowledge gained during the forty (40) years since the first Gates Crusher was put in operation.

Gates No. 27 Gyratory Crusher, having two openings, each 54"x141".



84"x66" Jaw Crusher

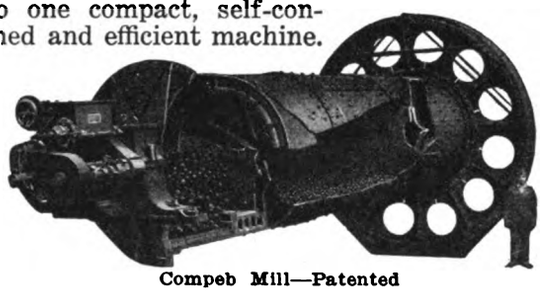
The company has also developed in all sizes Jaw Crushers for crushing copper ore, blast furnace flux and ballast stone.



60"x48" Fairmount Type (or Single Roll) Crusher

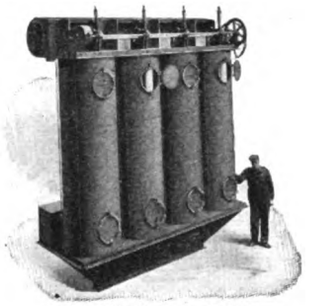
The Fairmount Crusher is intended to crush limestone, dolomite, phosphate rock, magnesite and other less tenacious rocks. It is not suitable for, nor do we recommend it for granites, trap rock or other igneous rock.

The Compeb mill is a two-stage grinding machine used for reducing raw materials from 1½-in. to any commercial fineness either wet or dry and is patented. This type of Mill has been successfully introduced in the cement and allied industries. The Mill combines the crushing, screening and grinding into one compact, self-contained and efficient machine.

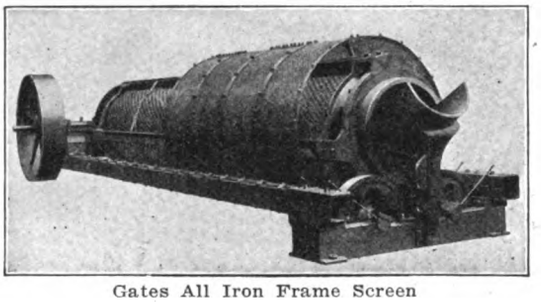


Compeb Mill—Patented

To meet the increasing demand for a machine which will successfully collect dust in large manufacturing establishments. the Allis-Chalmers Manufacturing Company has developed and is offering a bag filter type dust collector which is the first machine of this type to be designed, built and put into successful operation by any American manufacturer.

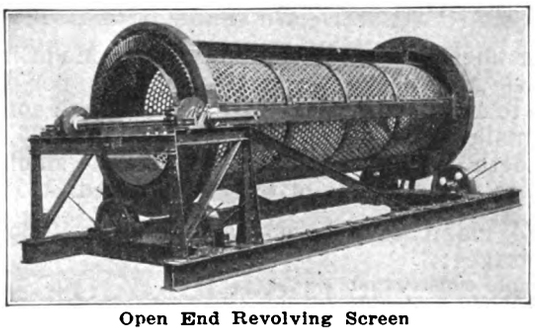


Allis-Chalmers Dust Collector



Gates All Iron Frame Screen

The durability, simplicity and efficiency of the Gates Patented All-Iron Frame Screens is unequalled by any other screen on the market.



Open End Revolving Screen

Gates Screens are built in numerous sizes, ranging from 24-in. diameter by 8 ft. long, to 72 in. diameter by 24 ft. long. Open End Scalping Screens of the Cylindrical type are built in sizes ranging from 48 in. to 72 in. diameter.

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McLANAHAN-STONE MACHINE CO.

ESTABLISHED 1836—INCORPORATED 1900

HOLLIDAYSBURG, PENNA.

Ore Washing Machinery and Rock Crushing Plants

Products

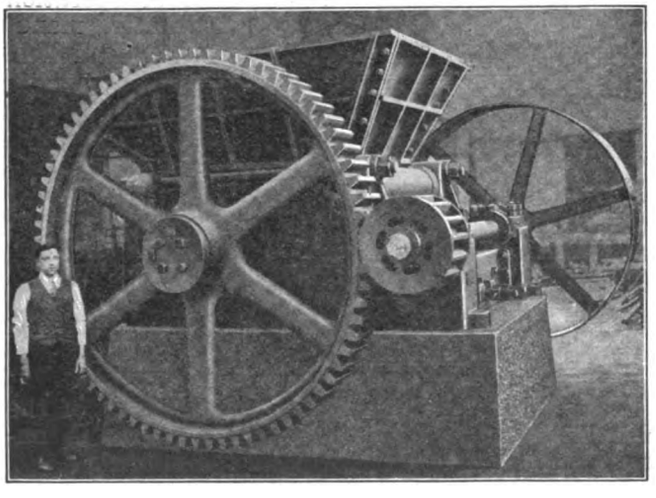
McLanahan's Single Roll Crusher; Complete Ore Washing and Rock Crushing Plants; Revolving Screens; Conveyors and Elevators; Picking Tables; Dryers; Log Washers—for Iron Ore, Manganese Ore, Phosphate Rock, Limestone, etc.; Jigs—for Iron, Manganese and non-precious Ores; Electric and Belt-Driven Hoists.

Service

Our firm has been engaged continuously in the manufacture of this special line of machinery since 1836. Our long experience in the making of machinery for the washing and preparation of iron and manganese ore, phosphate rock, etc., has permitted us to work out standard designs which give the maximum of durability and ruggedness, with ease and low cost of operation. To managers who wish to introduce special designs of their own, we offer the services of our engineering department.

The McLanahan Single Roll Crushers

These machines are strong and well built; the gearing extra heavy; the roll shell is a solid cylinder or shell of chilled charcoal iron. Made in capacities crushing from 5 to 500 tons per hour. Made to crush as small as ¾ inch, although some of the smaller sizes are crushing as small as ½ inch. The teeth or lugs or corrugations on the shells are made to suit the size of output required.



Single Roll Crusher

We claim for these machines the following advantages:

Simple construction.
All parts accessible for inspection or repairs.
Ready adjustment—only few moments required.
Wide range of output and less fines.
Low height compared with gyratory.
Less first cost, capacity considered.
Economy in operation.

Ore Washers

Located in the midst of the Pennsylvania iron ore fields, we have been for over 40 years manufacturing machinery for preparation of these ores, starting with the most primitive form of washers, both barrel and log; and have finally evolved our improved double log washer and other appliances used in connection with it.

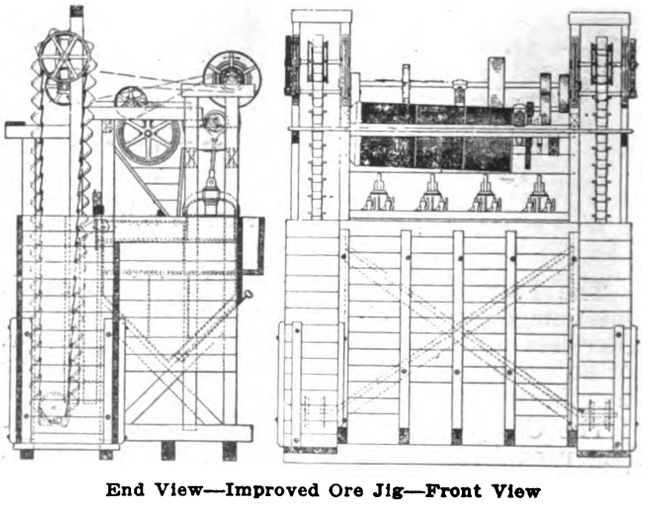
We make these washers equipped with either wood or steel logs. With the former we furnish all the iron work for the logs, but do not furnish the wood, as this can be more readily obtained at the point where the washers are to be erected than in our immediate vicinity. But when steel logs are to be used, these are made complete, ready to drop into the bearings.

Steel Logs for Washers

Are formed of four pieces of 6 inch by 6 inch by ¾ inch angles, securely fastened to flange gudgeons at each end extending between the angles for a distance of 20 inches. The paddles are of chilled charcoal iron placed between the sides of adjacent angles and held in place by two bolts. For extra heavy work we use 8 inch angles. Made in lengths up to 25 feet and to fit any size washer. Are extensively used for phosphate rock, hematite, iron ores, etc.

McLanahan's Improved Ore Jig

This jig has been perfected after a long series of experiments and trials under operating conditions and is specially suited for washing iron and manganese ores. It is made all of iron except the framing and hutch and the construction is apparent from accompanying elevations. We furnish the iron work or erect these jigs complete in any part of the country, employing experienced mechanics.



End View—Improved Ore Jig—Front View

Special Machinery Made From Specifications and Drawings to Suit Requirements of Customers

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Worthington Pump and Machinery Corporation

Executive Offices

115 Broadway, NEW YORK

Works

Worthington Works....Harrison, N. J.
Blake & Knowles Works.....
.....East Cambridge, Mass.
Deane Works.....Holyoke, Mass.
Power and Mining Machinery Works
.....Cudahy, Wis.

Works

Laidlaw Works.....Cincinnati, O.
Snow-Holly Works.....Buffalo, N. Y.
Hazleton Works.....Hazleton, Pa.
Gas Engine Works.....Cudahy, Wis.
Epping-Carpenter Works.....
.....Pittsburgh, Pa.

Branch Offices

ATLANTA, GA.....435 Trust Co. of Georgia Bldg.
BIRMINGHAM, ALA...American Trust & Savings Bank Bldg.
BOSTON, MASS. 2.....465 Massachusetts Trust Bldg.
BUFFALO, N. Y.....707 Iroquis Bldg.
CHICAGO, ILL.....820 Old Colony Bldg.
CINCINNATI, OHIO.....1503 First National Bank Bldg.
CLEVELAND, OHIO.....304 Kirby Bldg.
DENVER, COLO.....435 Seventeenth Street
DETROIT, MICH.....839 Majestic Bldg.
EL PASO, TEXAS.....510 Mills Bldg.
HOUSTON, TEXAS.....425 Southern Pacific Bldg.
KANSAS CITY, MO.....825 Scarritt Bldg.
LOS ANGELES, CAL.....209-210 Higgins Bldg.
NEW ORLEANS, LA.....533 Baronne Street
PHILADELPHIA, PA.....1516 North American Bldg.
PITTSBURGH, PA.....407 Oliver Bldg.
ST. LOUIS, MO.....701 Laclede Gas Bldg.
ST. PAUL, MINN.....1017 Commerce Bldg.
SALT LAKE CITY, UTAH.....318 Felt Bldg.
SAN FRANCISCO, CAL.....306 Sharon Bldg.
SEATTLE, WASH.....203 Maynard Bldg.
TULSA, OKLA.....123 West First Street
WASHINGTON, D. C.....426 Homer Bldg.
LONDON, ENGLAND.....Queen's House, Kingsway
PARIS, FRANCE.....Societe Francaise des Pompes et Machines Worthington, 1 Rue des Italiens
MEXICO CITY, MEXICO.....P. O. Box 5260

CRUSHERS AND SCREENS

Products

Crushers; Revolving Screens; Elevators; Conveyors. For other products see Pages 165, 166, 167, 176, 463, 626 and 741.

Superior McCully Crushers

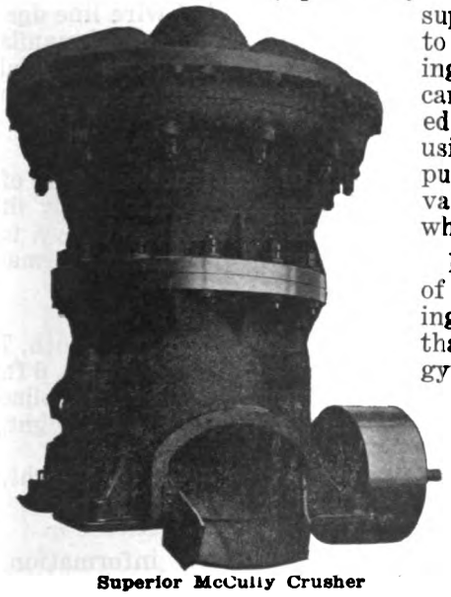
This crusher possesses many superior points, which may be enumerated as follows:

Spider—The hub of the spider is absolutely rigid, due to close coupling of shaft bearings, maintaining perfect alignment of bearing and reducing strain on spider.

Main Shaft—Due to placing eccentric directly below head, strength of shaft is increased 60% over any standard crusher of corresponding size, eliminating all shaft deflection and consequent breakage, and resulting in greatly increased crushing capacity.

Dust Ring—Improved type under head, excluding all dirt from eccentric bearing.

Oil Pump—Pump is of spur geared type, under constant feed of oil, positively delivering ample supply at all times to eccentric bearing and gearing—cannot be compared with systems using plunger pump and check valves, which are wholly unreliable.



Superior McCully Crusher

Eccentric—Area of eccentric bearing 100% greater than in standard gyratories.

Gears—Gear and pinion of cast steel with cut teeth running in oil, insuring smooth operation and long life.

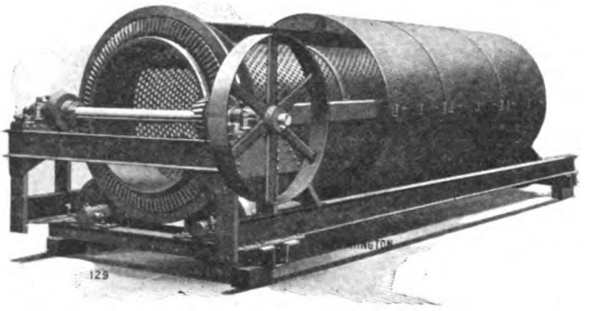
Sizes Built

The Superior McCully Crusher is built in sizes from openings 8 inches to 72 inches wide.

Open End Type Screens

Worthington manufactures screens of special large sizes and of very heavy construction for use in connection with Superior Jaw Crushers, these being required to handle the large pieces and enormous quantities of material discharged by these machines.

The screens are of the Open End type, having no obstruction of any kind to impede the discharge of the material, and there are, therefore, a minimum number of parts subject to wear, and those that do wear can be easily and cheaply replaced.



Standard Roller Type Bevel Gear Driving Screen, Steel Frame

The drums are provided with outside steel angle strut bars securely fastened to substantial cast iron heads.

Any of the screen sections can be removed without disturbing the others. Sections can be made of either punched steel plate or manganese steel castings. When so ordered, a dust jacket of perforated plate or wire cloth may be attached outside the bars. This jacket is made in sections and is easily removable.

SCHEDULE OF SIZES

Diam. in Inches	Length in Feet	R. P. M. Screens	R. P. M. Pinion Shaft
24	6, 8, 10, 12, 14, 16	23	100
48	8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28	16	80
60	10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30	13½	100
84	12, 14, 16, 18, 20, 22, 24, 26, 28, 30	11½	80

Elevators and Conveyors

Worthington also makes Bucket Elevators and Pan Conveyors.

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ARMSTRONG MANUFACTURING CO.

Home Office
WATERLOO, IOWA, U.S.A.
411 Chestnut Street
Branches
129 West Second Street
LOS ANGELES, CAL., U. S. A.
30 Church Street,
NEW YORK, N. Y., U. S. A.

Armstrong
MFG. CO. WATERLOO, IOWA, U.S.A.
BUILT FOR SERVICE
SINCE 1867

Factory
WATERLOO, IOWA, U.S.A.
410-430 Chestnut St.
Branches
112 Main Street
BOWLING GREEN, KY., U. S. A.
229 West Fifteenth Street
FT. WORTH, TEXAS, U. S. A.

Prospecting Drills—Water and Oil Well Drills—Blast Hole Drills

Type

Armstrong "All-Steel" drills are of the churn drill type, especially adapted to the following purposes:

(a) As blast hole drills for quarries and mines.

(b) Prospecting in zinc, lead, iron and other mineral fields.

(c) For gold testing in placer and hydraulic mining areas.

(d) For coal testing and vein tracing.

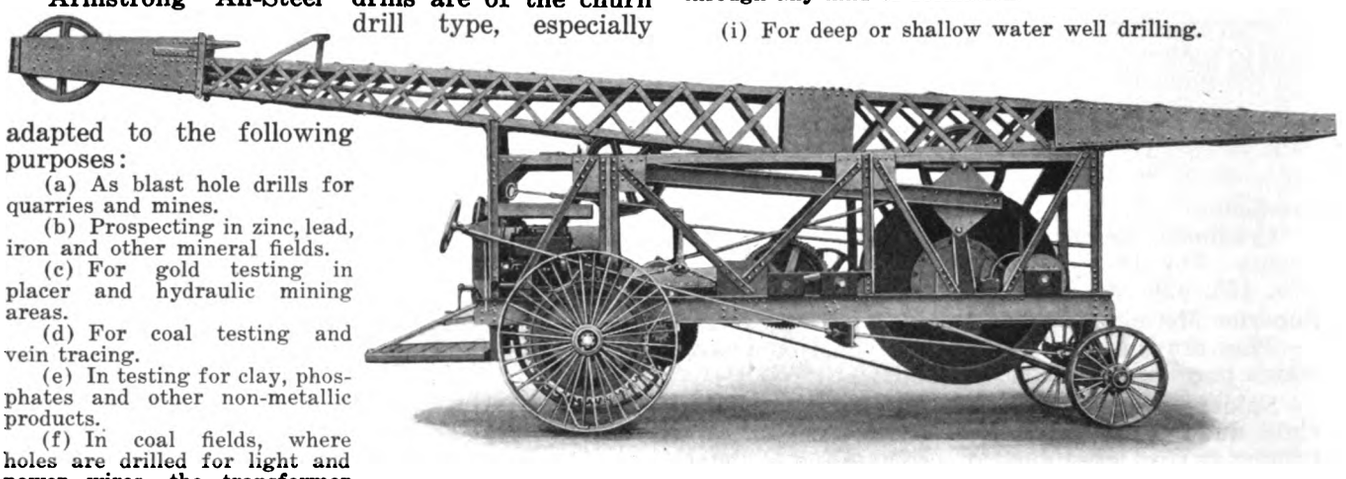
(e) In testing for clay, phosphates and other non-metallic products.

(f) In coal fields, where holes are drilled for light and power wires, the transformer being installed on the surface to save long electric lines.

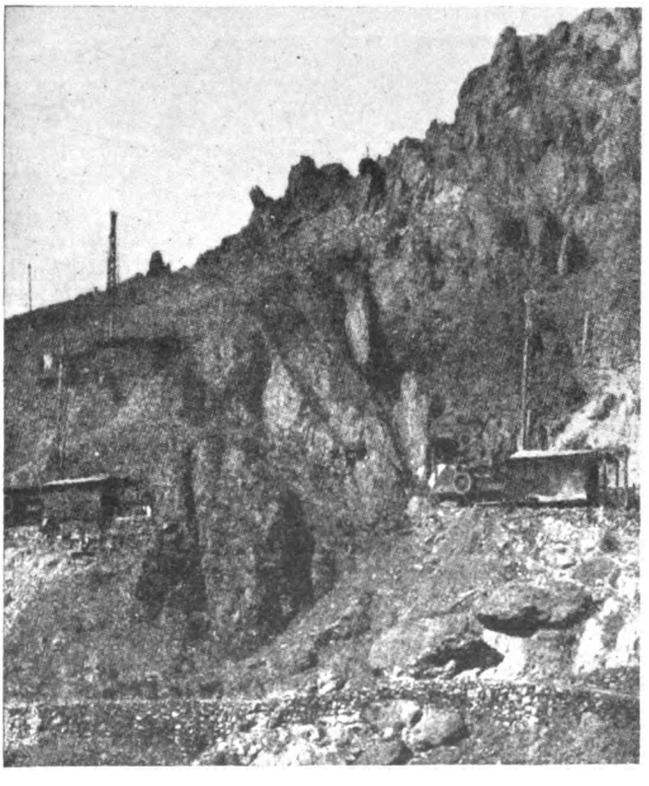
(g) In coal fields, where holes are drilled so that mine can be pumped vertically instead of installing gathering pumps and long lines of water main.

(h) For oil well drilling in either deep or shallow fields, through any kind of formation.

(i) For deep or shallow water well drilling.



Armstrong "All Steel" Drill. Tractor Model. Electric or Gasoline Power.



Showing three Armstrong Electric Power Drills, drilling a line of holes to cross-cut between two well mineralized areas of an Arizona copper mine.

Construction

All steel. Channel beams and angles trussed and hot riveted. Wheels, axles, standard steel type. Derrick: latticed steel. No danger of damage from flying stone from blasts. No danger from fire. Tractor models.

Equipment

General Electric Motor, or 4-cylinder gasoline engine of standard make, furnishes operating and tractive power. Armstrong patented wire line derrick uses steel wire cable at half the cost of manila cable, and four times the life. Armstrong special controls enable operator to control entire operation from the drilling end.

Uses

The strength, stability of construction, ease of control, and 55 years of experience, peculiarly fit Armstrong drills for the purposes named above, to any depth up to 3000 ft. through any natural formation.

Specifications

No. 50 (shown above): Length, 22 ft.; width, 7 ft. 10 in.; height of derrick, 32 ft.; band wheel, 6 ft. in diam., 11 in. face.; power unit, 4-cylinder gasoline engine or General Electric Motor, if desired; weight, complete, 14,900 lbs.

No. 60 (not shown): Capacity, 3000 ft.; weight, 42,000 lbs. Other specifications in comparison.

Information

Catalogs free. In writing for information, please state:

1. For what purpose desired.
2. Diameter and depth of hole required.
3. Describe formation, if known.
4. Do you want electric or gasoline power?

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The Sanderson-Cyclone Drill Company

ORRVILLE, OHIO

NEW YORK OFFICE: 30 CHURCH STREET

Big Blast Hole Drills—Prospecting and Well Drilling Machinery

Products

Blast Hole Drills; Churn Drills; Prospecting Drills; Well Drilling Machinery and Supplies.

Big Blast Hole Drilling

Churn drilling for blasting in open cut mines and in quarries producing crushed stone, now commonly known as big blast hole drilling, is a comparatively new system of operation, having been employed for only a little more than twelve years. It may be defined as the application of the cable tool system of well drilling to the drilling of holes for the purpose of loading explosive preparatory to blasting for rock excavation.

Big blast holes may be drilled in different sizes, ranging from 3 inches to 8 inches in diameter, the size usually being determined by the character of the material and amount and kind of explosive necessary for blasting it. This system of operation will work successfully on ledges varying from 15 to 200 feet in height, the holes usually being drilled and blasted the full depth of the cut. Deviations from this practice are sometimes necessary, especially as regards the height of the working face, as it has been found that the most economical results may be obtained by working breasts ranging from 35 to 60 feet in height.

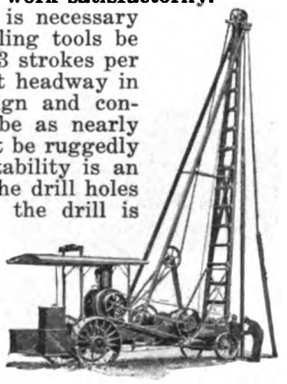
Briefly stated, the advantages of big blast hole drilling over benching, snake holing and tunneling —the other most important systems of open cut drilling and blasting—are as follows: (1) Bench cleaning with its dangers and delays is eliminated; (2) Material is brought down to one working level; (3) Material is thoroughly shattered so that very little secondary drilling and blasting is required; (4) Drilling can be carried on at the same time as shovel operations, as the drills are on different working levels; (5) Combined drilling and explosive costs are less; (6) Springing of drill holes is seldom necessary, as the large diameter of big blast holes will accommodate the requisite amount of explosive in the bore of the hole.

An Open Pit Copper Mine in Arizona. 3 of the 15 No. 14 Cyclone Drills used on this work are shown in the photograph.

Cyclone No. 14 Big Blast Hole Drills

Less than a year after churn drills were first introduced on open cut mine operations, the Cyclone No. 14 Special Blast Hole Drill was placed on the market because it was evident that big blast hole drilling was more than an ordinary well drilling proposition and a special type of machine was necessary to take care of this work satisfactorily.

For big blast hole drilling, it is necessary that a heavy string of cable drilling tools be operated at a high speed—60 to 63 strokes per minute—in order to make efficient headway in hard rock formations. The design and construction of the machines must be as nearly fool-proof as possible. They must be ruggedly built and still not heavy, as portability is an important consideration because the drill holes are comparatively shallow and the drill is moved frequently.



No. 14 Standard Gasoline Traction Drill.

The drilling mechanism of the Cyclone No. 14 drills is so designed as to take care of the speedy operation required. The main metal operating parts are of cast steel, eliminating the chance for breakage. The frame is of straight grained Oregon fir, a wood that is as strong and durable as oak but is much lighter than oak. The sills are thoroughly braced and the machinery evenly balanced on the sills.

The Cyclone No. 14 Blast Hole Drills are built in two sizes—the No. 14 Junior and the No. 14 Standard—and may be had in either traction or non-traction type with gasoline, steam or electric power equipment. In electric power, motors of any current specification desired will be furnished. The No. 14 Junior Drill is best suited for "light" blast hole work—the drilling of 3" to 5" holes in material of medium hardness such as shale, sandstone and the average run of overburden stripping. For maxium results and footage, and hard rock work the No. 14 Standard should be employed, with drilling tools for 5½" to 6" holes. In extremely hard and abrasive materials even larger holes should be drilled.

Blast Hole Drill Catalog

We have prepared a 100 page catalog No. BD-45 entitled "Big Blast Hole Drills." 40 pages of this catalog are devoted exclusively to semi-technical information on the subject of big blast hole drilling. Considerable operating and cost data is given in these pages. The balance of the book describes the Cyclone No. 14 drills in detail, as well as the cable drilling tools that are used in their operation.

Cyclone Well Drills

In addition to the blast hole drills, we build a full line of well drilling machines, in five sizes, with capacities varying from 200 to 2000 feet. These machines are furnished in both traction and non-traction types with either gasoline or steam power and are fully covered in our 160 page general catalog AM-70. These machines are suitable for drilling holes from 2 inches to 20 inches in diameter and may be used for the following purposes:

(1) Prospecting and testing the location and thickness of mineral deposits, such as coal, placer gold, iron, copper, lead and zinc.
(2) Drilling oil and gas wells.
(3) Drilling wells for mine and camp water supply.
(4) Drilling holes into underground mines for conductor lines for drainage and ventilation purposes and for steam, air, electric and water lines.

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THE MARION STEAM SHOVEL CO.

MARION OHIO

District Sales Offices

NEW YORK—50 Church Street
SAN FRANCISCO—741 Monadnock Bldg.
CHICAGO—1442-1443 Monadnock Block
ATLANTA—307 Candler Building

Sales Representatives at

Philadelphia, Pittsburgh, Detroit, Denver, Salt Lake City, Seattle, Spokane, Portland, Los Angeles, New Orleans, St. Louis, Fort Smith, Ark.; Billings, Mont.; Dallas, Tex.

Products

Manufacturers of Steam, Gasoline and Electric Shovels in revolving and railroad types ranging in size from ¾ to 8 cubic yards dipper capacity.

Dragline, clamshell and orangepeel excavators with booms ranging in length from 35 to 150 feet.

Dipper, clamshell and hydraulic dredges.

Placer elevator dredges for mining of gold, platinum or tin.

SMALL REVOLVING SHOVELS

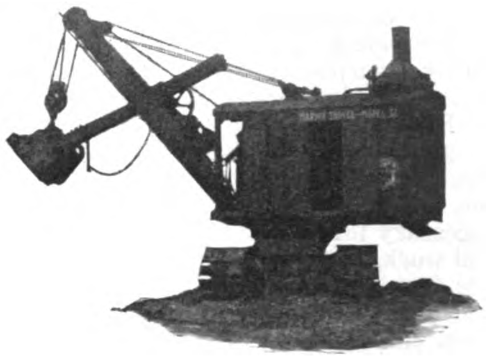
Steam, Gasoline or Electric Power. Crane Attachments. **Crawling Traction, Railroad Wheels or Wide Faced Traction Wheels.**

Model 37 Electric Shovel

Models 21, 32 and 37 cover the entire field of application for shovels in the small revolving class. They are of powerful and rugged construction, built to withstand continuous heavy duty.

Each Model can be furnished with steam, gasoline or electric power and with any one of three types of mounting—crawling traction, railroad wheels or wide faced traction wheels.

High Lift Equipment can be supplied where extra reach or height dump is required. Shovel and crane attachments are interchangeable on the same machine, thus adapting each model to a large variety of work.



Model 32 Steam Shovel

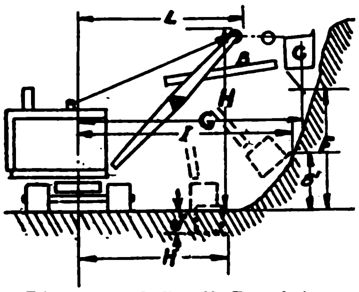


Diagram of Small Revolving Shovel

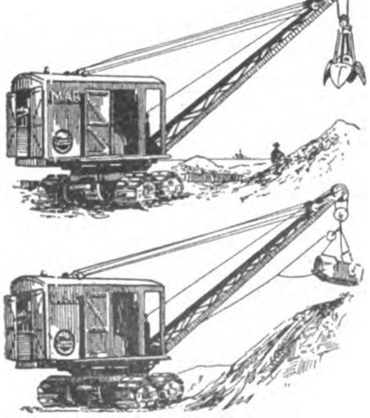
WORKING RANGES
Standard and High Lift Shovels—Mounted on Crawling Traction Trucks

Boom at Angle of 47½°	Model 21			Model 32			Model 37		
A—Length of Boom	17′6″	20′0″	22′0″	21′0″	24′0″	27′0″	25′0″	28′6″	32′0″
B—Length of Dipper Handle	12′6″	15′0″	15′0″	15′0″	17′6″	17′6″	17′0″	19′0″	22′0″
C—Size of Dipper cu. yds.	¾	¾	⅝	1¼	1¼	1	1¾	1¾	1¼
D—Capacity per Hr., cu. yds.	30–60	30–60	30–60	50–100	50–100	50–100	70–140	70–140	70–140
E—Approx. Working W'ght, lbs.	54000	57000	57500	80000	84500	85500	121000	126500	129000
F—Height of Dump	13′6″	15′0″	16′7″	16′7″	19′10″	21′6″	18′4″	21′9″	25′1″
G—Radius of Dump	22′6″	25′4″	25′9″	25′9″	28′7″	29′5″	29′9″	32′7″	36′1″
H—Radius of Cut at Grade	16′8″	17′5″	18′4″	18′2″	19′6″	20′0″	21′6″	23′2″	24′8″
I—Radius of Cut at 8 ft. Elevat'n	25′0″	27′11″	28′4″	28′6″	31′8″	31′10″	32′3″	35′0″	38′3″
J—Depth of Cut	3′7″	5′6″	5′0″	4′9″	6′2″	4′8″	5′1″	5′9″	6′10″
K—Height of Boom	18′2″	20′0″	21′6″	22′0″	24′2″	26′5″	25′7″	26′5″	30′9″
L—Radius of Boom	16′4″	18′0″	19′4″	19′5″	21′6″	23′5″	22′11″	27′0″	27′7″

THE VERSATILITY OF MARION REVOLVING SHOVELS

With Crane Attachments and With Crawling Traction Mounting

Model 21 carries a 35 ft. structural steel boom and has a lifting capacity of 6,500 lbs. at a radius of 35 feet. It can be equipped with a ¾ cubic yard dragline or clamshell bucket, or a 15 cu. ft. orangepeel bucket.

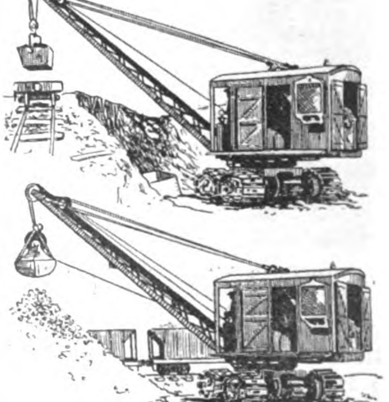


Crane Attachments

Model 32 crane boom is 40 feet long. With the point of the boom swinging on a radius of 40 feet, this model has a lifting capacity of 10,000 pounds. Dragline or clamshell bucket has a capacity of 1 cubic yard—orangepeel bucket 21 cubic feet.

Model 37 carries a 50 ft. boom when equipped as a crane, or as a dragline, clamshell or orangepeel excavator. It will lift 11,500 pounds at a radius of 50 feet. When used as a dragline or clamshell excavator, the bucket has a capacity of 1½ cubic yards. Orangepeel bucket is heavier and has a capacity of 1¼ cubic yards.

A power driven boom hoist is furnished as part of the regular crane equipment. The boom can be raised or lowered as desired, thus increasing or decreasing the lifting capacity, depending on the angle at which the boom is suspended.



Crane Attachments

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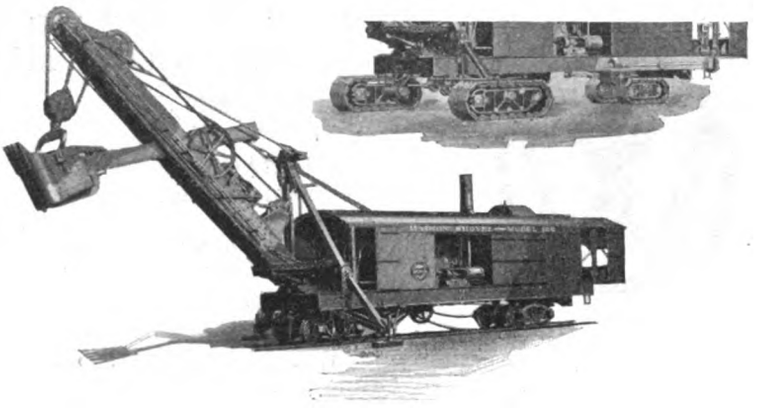
RAILROAD TYPE SHOVELS

We began building these in the early eighties. One of this type, shipped into the Lake Superior District in 1891, was the first shovel ever bought for iron-ore service. Since then the line has been developed and its usefulness extended to almost every kind of heavy excavating.

Shovels of this design have the operating machinery, swinging circle and boiler mounted on a car body, the boom swinging through an arc of 190 to 260 degrees, depending on the size of the shovel.

They can be furnished with railroad trucks or with wide faced traction wheels. With the exception of Model 41 all shovels of this type can be equipped with crawling traction trucks—a mounting admirably suited to mine or quarry. (Upper view at right).

Models 51, 61, 70 and 92 can be furnished with electric power and several of the smaller models can be fitted for compressed air for tunnel work or underground mining.



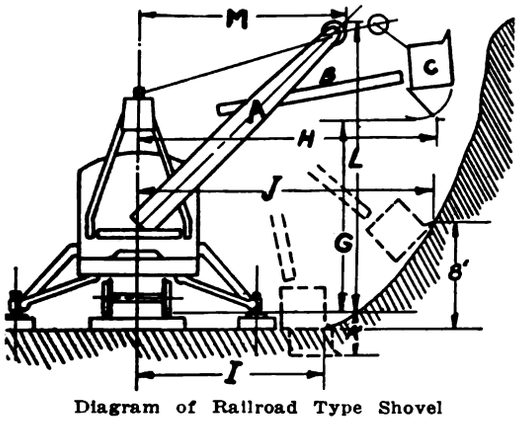
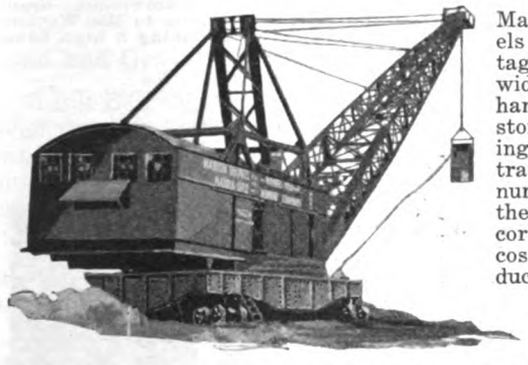


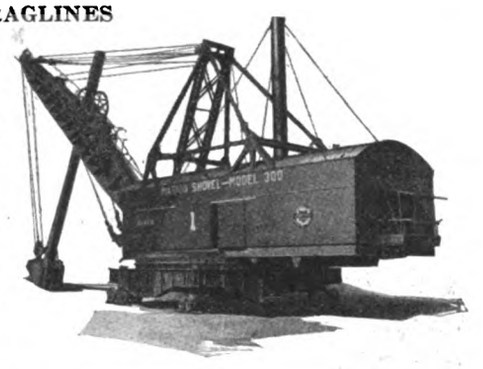
Diagram of Railroad Type Shovel

WORKING RANGES
Railroad Type Steam Shovels — Mounted on Railroad Trucks

	Model 41	Model 51	Model 61	Model 70	Model 76	Model 92	Model 100
A—Length of Boom	20'0"	23'0"	25'0"	27'0"	28'0"	30'0"	32'0"
B—Length of Dipper Handle	12'6"	15'0"	16'0"	17'0"	18'6"	19'6"	19'6"
C—Size of Dipper	¾–1½	1½–2¼	2–3	2–3½	2½–4	3–5	3–6
D—Capacity per Hour, cu. yds	60–80	80–270	120–350	125–375	150–400	200–500	250–550
E—Approx. Working Weight, lbs	92000	132000	159000	182000	212000	239000	266000
F—Boom Swings Back of Right Angle	40°	10°	10°	5°	5°	5°	5°
G—Height of Dump	12'0"	14'6"	16'0"	16'6"	17'0"	17'0"	17'0"
H—Radius of Dump	20'4"	24'3"	25'10"	27'4"	29'0"	31'2"	31'1"
I—Radius of Cut at Grade	13'6"	15'6"	17'0"	18'0"	19'0"	20'0"	20'0"
J—Radius of Cut at 8 ft. Elevation	23'0"	25'6"	29'0"	30'0"	31'0"	33'0"	33'0"
K—Depth of Cut Below Wheels	4'4"	4'11"	5'0"	5'2"	6'2"	6'9"	6'1"
L—Height of Boom	19'6"	23'0"	24'7"	26'6"	27'7"	29'6"	31'4"
M—Radius of Boom	15'10"	18'0"	19'9"	21'2"	21'10"	23'4"	24'9"

LARGE REVOLVING SHOVELS AND DRAGLINES





In mining and quarry service Marion Large Revolving Shovels have many distinct advantages over other types. Their wide working range in the handling of overburden, ore or stone cause less frequent shifting of the working and loading tracks and greatly reduces the number of men required about the machine. Output can be correspondingly increased and cost per yard materially reduced.

Where deep overburden is encountered or extreme maximum reach and height dump are required, dragline equipment can often be used to an advantage. Shovel and dragline attachments are interchangeable on the same machine. Models 282 and 300 can be furnished with steam or electric power—all other models with steam only.

WORKING RANGES
Large Revolving Dragline Excavators
Single Boiler Truck Mounting

Boom at Angle of 30°	Model 222		Model 262		Model 282	
A—Length of Boom	70'0"	90'0"	100'0"	125'0"	125'0"	150'0"
B—Size of Bucket, cu. yds	3	2	4½	3½	6	5
C—Capacity per Hour, cu. yds	60–200	60–200	125–300	125–300	175–400	175–400
D—Height of Dump Above Rail	26'0"	37'0"	38'0"	54'0"	47'0"	62'0"
E—Radius of Dump	69'0"	86'0"	96'0"	118'0"	123'0"	145'0"
F—Radius of Cut at Grade in ft.	69–84	86–103	96–116	118–140	123–145	145–175
G—Depth of Cut	29'0"	42'0"	28'0"	29'0"	38'0"	40'0"
H—Approx. Working Weight, lbs	198000	198000	383000	383000	689000	689000

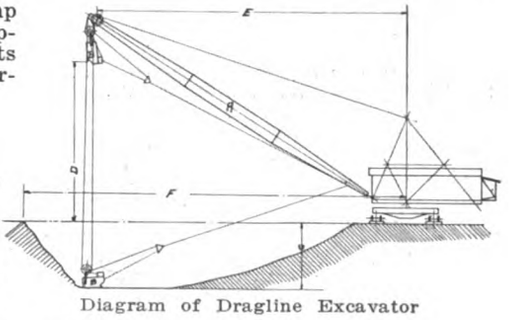


Diagram of Dragline Excavator

WORKING RANGES
Large Revolving Shovels
Single Boiler Truck Mounting

Boom at Angle of 45°	Model 212		Model 252	Model 300	
A—Length of Boom	45'0"	55'0"	75'0"	80'0"	90'0"
B—Length of Dipper Handle	28'0"	34'0"	46'0"	52'0"	54'0"
C—Size of Dipper, cu. yds	2	1½	3½	8	6
D—Capacity per Hour, cu. yds	75–150	75–150	100–200	150–300	150–300
E—Approximate Working Weight, lbs	205000	205000	410000	722000	722000
F—Height Dump Above Rail	33'0"	42'0"	53'0"	56'0"	65'0"
G—Radius of Dump	52'0"	62'0"	82'6"	95'0"	99'0"
H—Radius of Cut at Grade	33'0"	37'6"	5'10"	57'0"	60'0"

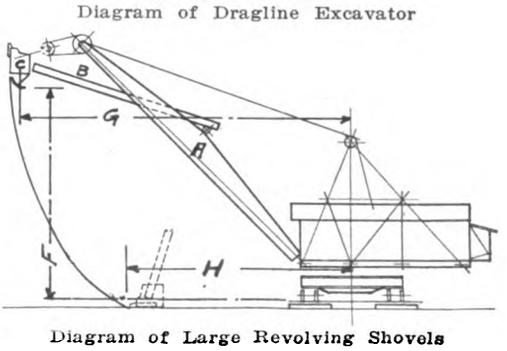


Diagram of Large Revolving Shovels

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Locomotive, Erection and Wrecking Cranes, 5 to 200 tons capacity. Pile Drivers, Pillar Cranes, Transfer Cranes, Gantry Cranes, Crawling Tractor Cranes, Rail Saws, Transfer Tables, Grab Buckets, Double-Acting Steam Pile Hammers, Wood Grapples; Buckets—Coal and Ore.

"INDUSTRIAL" Cranes Increase Profits by Reducing Costs

Steam, gasoline, or electrically operated Locomotive Cranes for bucket, dipper, or magnet operation; yard service and construction work; with capacities ranging from five tons to sixty tons; booms to suit, varying from 40 ft. to 140 ft. in length.

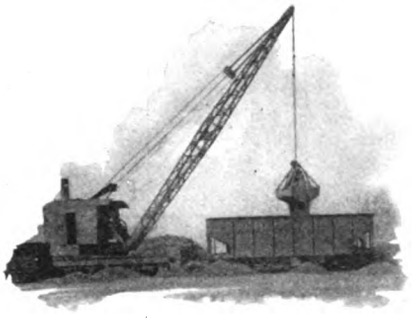
Cranes and Pile Drivers furnished to suit any gauge, clearance, and axle load requirements.

"INDUSTRIAL" Cranes are built so as to be readily convertible for various operations. The same Crane may be used for pile driving, magnet operation, automatic bucket operation and for handling heavy loads with hook and block. Booms may be built in sections so that the length may be quickly changed to meet various conditions. The propelling mechanism is of a powerful, sturdy type that makes the Crane efficient in switching and hauling heavily loaded cars.

"INDUSTRIAL" Cranes are pre-eminently adapted to the needs of caring for the many rush jobs on the range, placing over-turned ore cars on the tracks, erecting structural steel head-frames, and concentrators, work about the shops, coaling steam shovels, shunting cars, lifting and shifting track sections and countless other duties.

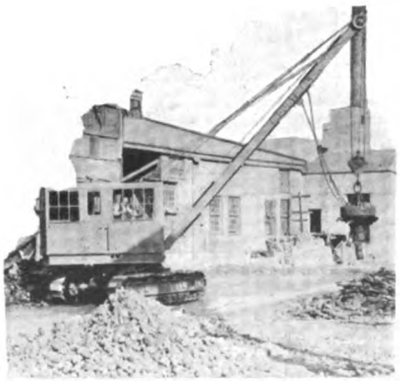
If your own requirements are somewhat special, a detailed inquiry will receive the most careful consideration and study by a corps of engineers who will take pleasure in recommending the proper equipment.

General Catalogue No. 110, Bucket Catalogue No. 111, Book No. 113, describing our CRAWLING TRACTOR CRANE as illustrated herewith, will be forwarded on application.



Type G "INDUSTRIAL" Crane of The Baldwin Locomotive Works handling coal with "INDUSTRIAL" Power Wheel Bucket.

Type K "INDUSTRIAL" Crane belonging to the Oliver Iron Mining Co.



Type BC "INDUSTRIAL" CRAWLING TRACTOR CRANE of 10 tons capacity equipped with magnet handling pigs.

"INDUSTRIAL" Pile Driver for driving piles either close to the machine on either side of the track, or at varying distances ahead of the driver, and driving batter piles when desired.

"INDUSTRIAL" Convertible Crane Steam Shovel belonging to the Western Maryland R. R., trimming a high bank.

Type L "INDUSTRIAL" Crane belonging to the Sullivan Granite Co., Westerly, R. I., handling block of granite.

Type K "INDUSTRIAL" Crane handling mine machinery for the Nevada Consolidated Copper Co.

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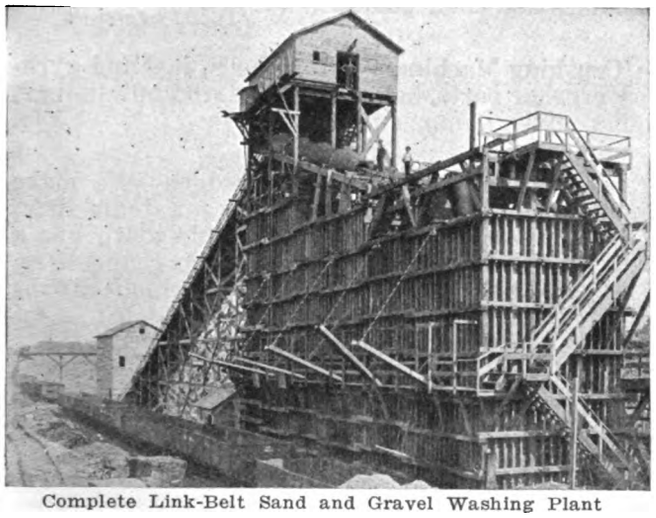
For Description of Other Products See Pages 208, 653, 654 and 655



Complete Link-Belt Sand and Gravel Washing Plant

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Link-Belt Equipment is standard the country over for the handling, preparation and storing of sand and gravel. Each installation is designed and built to fit the individual conditions and requirements in every case.

Our engineering service is at your command without charge. Send for book No. 440, illustrating some of the numerous Link-Belt plants.

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The possibilities for great savings, both in labor and time, by employing Link-Belt machinery in handling stone and lime, are many. There are more wheel-barrows and muscles used in handling stone and lime than in any other large industry. We can eliminate a lot of it and save you the cost of investment in less than two normal years. Send for book No. 416, showing the entire line of Link-Belt stone and lime handling equipment.

Lime being fed from a flame kiln bin to pan conveyor on floor. This pan conveyor travels up an incline at the end, delivering to a shaking screen.

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The crawler crane is the latest addition to the long line of Link-Belt material handling equipment. It is an ideal machine for any odd jobs around the plant. It is rugged, responsive and mobile, yet light in weight. Its performance will convince you of its exceptional quality and economy. Send for new bulletin No. 595.

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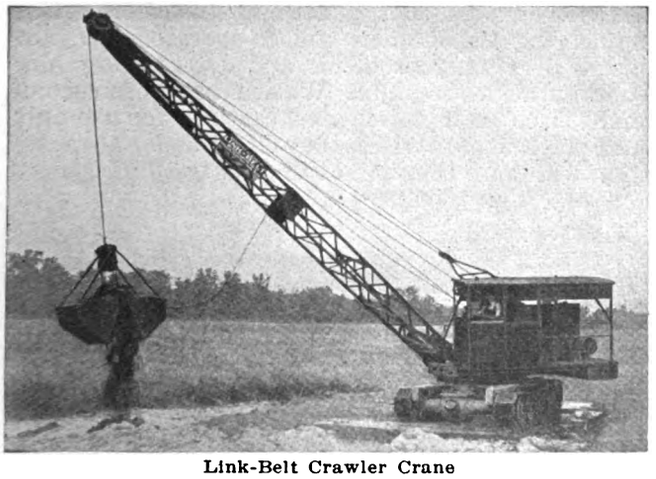
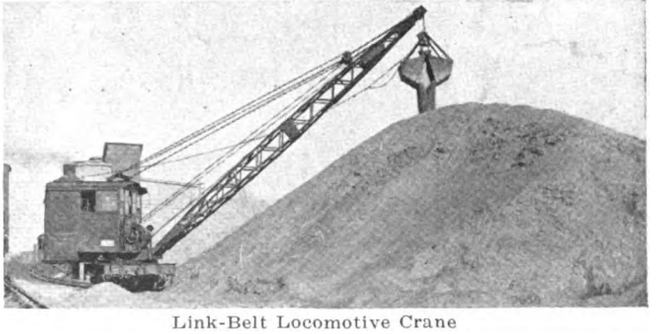
Represents the highest degree of efficiency in design and mechanical construction known in the crane building art. Provided for all classes of service with grab-bucket, hook, sling or lifting magnet. Can do the work of from 20 to 30 men. Send for book No. 370.



Link-Belt Crawler Crane



Link-Belt Locomotive Crane

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Taylor-Wharton Iron and Steel Company

FOUNDED 1742

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Products

Alloy Steel; Castings—Steel and Alloy Steel; Dippers and Parts for Steam Shovels; Buckets, Tumblers, Links, Pins and Bushings for Dredges; Wheels—Mine Car and Roller Bearing; Chain—Conveyor and Elevator; Teeth for Dredge Dippers.

"Tisco" Manganese Steel

Physical Properties—"Tisco" manganese steel contains 1.00 to 1.25 per cent. carbon, 0.30 silicon, 12.50 manganese, less than 0.02 sulphur, and about 0.08 phosphorus; it was first successfully produced in the United States by this company in 1892, under exclusive license of the Hadfield patents. Many refinements in the method of melting, heat treating, moulding and finishing have since been introduced and perfected. Our method of scientific heat treatment reduces brittleness, and renders it tough and ductile. It has a high tensile strength and is extremely resistant to wear. Manganese steel will not stand direct exposure to excessive heat in service. It is non-magnetic.

Advantages—"Tisco" manganese steel may be used to great advantage for castings (where machine finishing is not intricate) in place of cast iron, malleable iron or ordinary steel because of its resistance to shock, heavy wear and abrasive action; its wear-hardness is remarkable. It may be used to advantage, also, where time is so important a factor that the cost of a shut-down for replacement means more than the first cost of repair parts; and where machinery is located a long distance from a railroad or other shipping facilities and breakdowns entail loss of time and reduce production.

Uses—Manganese steel has found its most noteworthy uses in the construction of the following machines and their parts:

Crushing Machinery—Roll shells, jaw and gyratory crusher parts, ball mill linings, rod mill linings, chilian mills, hammer mills.

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Placer Dredges—"Tisco" manganese steel buckets, tumblers, links, pins and bushings for gold and tin dredges make it possible to operate in ground which would otherwise be unprofitable.

Mine and Skip Car Wheels—"Tisco" manganese steel mine car wheels will operate continuously for years without breakage and with practically no wear. They are made with plain or self-oiling hubs or roller bearings.

Chain, Sprockets and Conveyor Parts—"Tisco" manganese steel is used to make practically every standard type of chain for elevating and conveying. All chain is tested before shipment and rigidly inspected.

Service

The company is one of the oldest manufacturing concerns in the United States with a continuous existence under Taylor leadership since 1742. Our Engineering Department will co-operate with purchasers in solving problems and determining how to obtain the best results. We are careful to recommend "Tisco" manganese steel castings for use only where the economy which they effect under abrasive action will more than offset their extra first cost.

"Tisco" Manganese Steel Two-Part Panama Dipper Teeth

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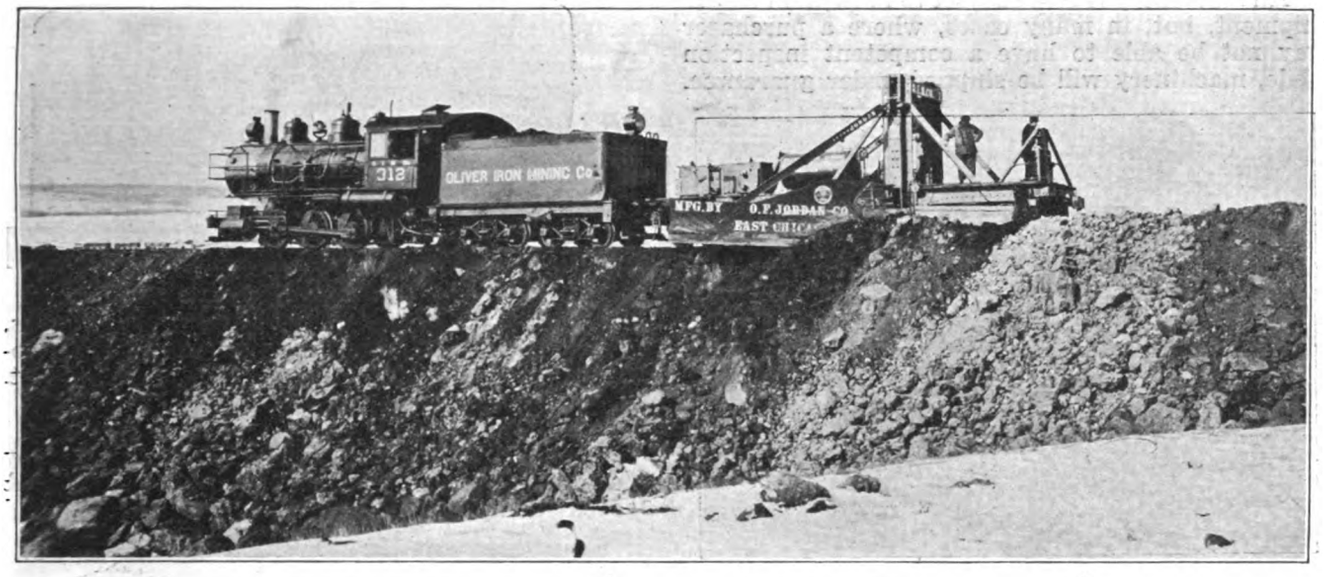

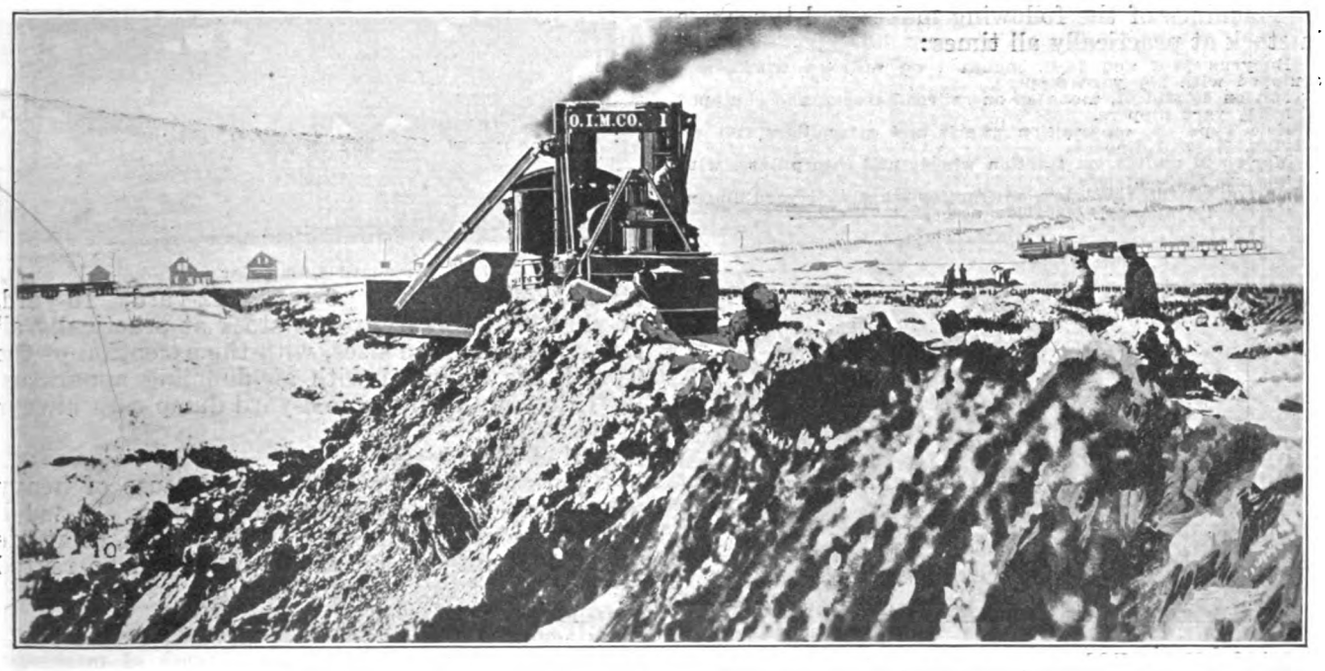

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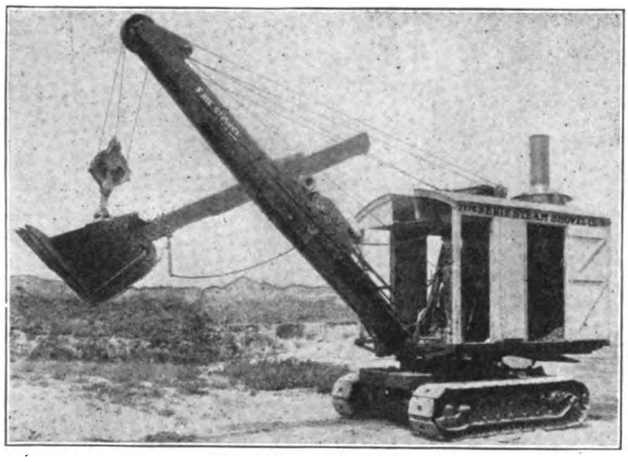
Rebuilt modern earth handling machinery, such as steam shovels, locomotive cranes, draglines, locomotives, dump cars, as well as pumps, compressors and other accessory equipment.

Methods

This company buys modern machinery from contractors who have finished jobs, and from Pit and Mine owners and Industrial concerns who have machinery of this nature to dispose of. No antiquated, worn out or abused machinery is purchased.

All machinery purchased is thoroughly repaired and re-built in fully equipped repair shops located on Neville Island, near Pittsburgh, Pa.

All machinery is sold subject to inspection before shipment, but, in many cases, where a purchaser may not be able to have a competent inspection made, machinery will be shipped under guarantee.



Steam Shovel

Steam Shovels

Machines of the following makes and types are in stock at practically all times:

Bucyrus 70-C and 78-C, mounted on railroad trucks and equipped with 2½ yard dippers.

Marion 60 and 61, mounted on railroad trucks and equipped with 2½ yard dippers.

Erie Type "B" on traction wheels and caterpillars full revolving, ¾ yard dippers.

Marion 21 and 28, on traction wheels and caterpillars, with ⅝ and ¾ yard dippers.

Osgood 18, full revolving, on traction wheels, ¾ yard dipper.

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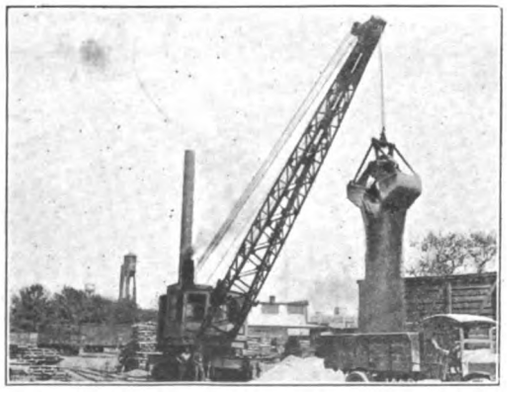
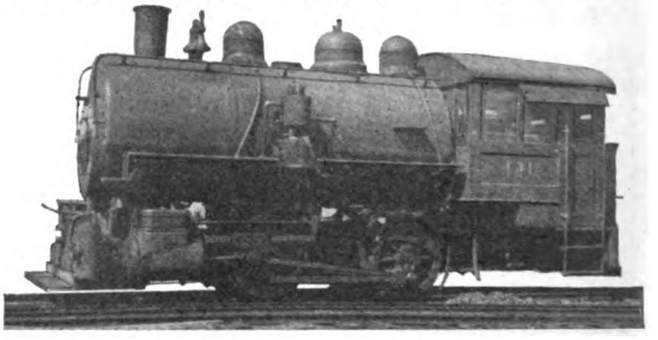


Locomotive Cranes

15 to 35-ton capacity, standard gauge Locomotive Cranes, of various makes, equipped with double drums for handling clam shell buckets, are on hand at practically all times. Larger and smaller sizes are frequently in stock.

Locomotives

Standard gauge saddle tank and switching locomotives, varying from eighteen to sixty tons in weight, are on hand at practically all times. Other sizes and types are frequently in stock.

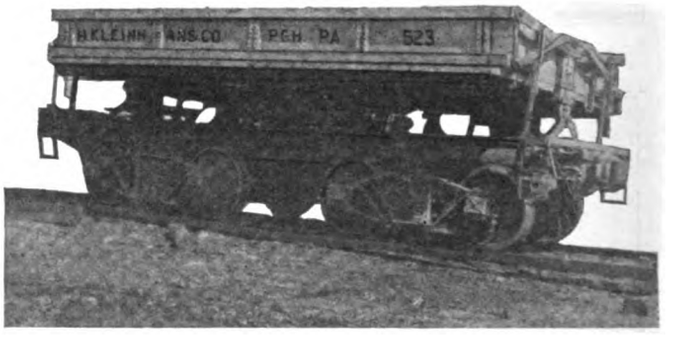


General Haulage Locomotive

Specialty is made of 36″ gauge locomotives, varying in weight from ten to twenty tons. Locomotives of this size are always ready for shipment. Larger one are frequently stocked.

Dump Cars

Standard gauge dump cars, manufactured by Western Wheeled Scraper Company, Kilbourne & Jacobs Company, Magor Car Corporation, and



Standard Dump Car

others, of capacities 6-yard, 12-yard, 16-yard, 20-yard, and 30-yard are in stock at practically all times. All of these sizes, with the exception of the 6-yard, are equipped with air-dumping apparatus.

Thirty-six inch gauge 4-yard dump cars always in stock.

Rental of Machinery

Operators frequently require the use of heavy excavating machinery for special purposes, such as siding construction, etc. In such cases, complete excavating outfits or separate units can be rented for periods of two months or more.

Miscellaneous Equipment

In addition to the above listed machinery, there are in stock at all times various sizes and types of machinery required on construction work, such as steam, electric and gasoline operated pumps; steam, electric and gasoline operated concrete mixers; well drills; hoisting engines; road rollers; steam hammers, etc., etc., etc.

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SECTION XIII

Aerial Tramways and Cableways

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

American Steel & Wire Co.
Broderick & Bascom Rope Co.
Interstate Equipment Corp.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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CABLEWAY AND TRAMWAY DATA

CABLE FORMULAS

Catenary Curve

Theoretical curve taken by a cable of uniform weight when suspended from its ends is a catenary; it is the curve of the funicular polygon formed by a series of equal weights hung equidistant along the arc.

Empty Cable; Horizontal Chord. In Fig. 1, let

s = span, ft.
h = deflection at center, ft.
h_1 = deflection at any point of curve, as p, ft.
t = tension in cable at center, lb., = horizontal component of tension at any point.
T = tension in cable at any point, lb.
w = weight of cable per ft. lb.
W = total weight of cable in span, lb. = ws.
R = total vertical reaction at a tower; for cable only, it is ½W = ½ws.
m and n = sections into which point p divides span.
ϕ = inclination of tangent to curve at any point, as B.

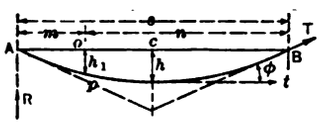

Fig. 1

Deflection at Center

$$h = ws^2 \div 8t$$

Deflection at Any Point, as p

$$h_1 = wmn \div 2t$$

Tension of Cable at any point is:

$$T = t \div \cos \phi$$

Slope of Tangent to Curve of Empty Cable

The tangent at end of span, when chord is horizontal, has a slope of

$$\tan \phi = R \div t.$$

Let Fig. 2 be the funicular polygon resulting from three concentrated loads, then,

H = the total deflection due to load and cable

$$= \frac{r_1 m}{t} + \frac{wmn}{2t}$$

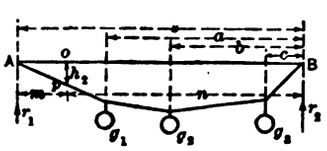

Fig. 2

WORKING EQUATION FOR CENTER DEFLECTION OF HORIZONTAL SPAN

Type of cable	w, lb.	t, lb.	Working equation
Smooth-coil cable...	3.4	30,000	$h = .000011\ s^2$
Locked-coil cable...	3.6	30,000	$h = .000015\ s^2$
Patent-locked rope..	*	⅓ ult. strength	$h = .000014\ s^2$
		⅙ ult. strength	$h = .000018\ s^2$

*For patent-locked rope from 1 to 2.25 in. diam., the mean value of weight ÷ ult. strength = .000029.

WEIGHT AND STRENGTH OF TRACK CABLES

Diam. Inches	Locked-Coil Cables			Smooth-Coil Cables			Patent-Locked Rope		
	Weight lb. per. ft.	Ultimate Strength lb.	Working tension lb.	Weight lb. per. ft.	Ultimate Strength lb.	Working tension lb.	Weight lb. per. ft.	Ultimate Strength lb.	Working tension lb.
⅞	1.87	56,800	15,780	1.55	49,360	13,710	1.88	72,000	14,400
1	2.36	71,300	19,820	2.03	64,460	17,900	2.50	86,000	17,200
1⅛	2.87	86,100	23,910	2.57	81,580	22,660	3.15	110,000	22,000
1¼	3.60	108,700	30,210	3.18	100,890	28,020	3.80	134,000	26,800
1⅜	4.30	131,600	36,560	3.72	118,270	32,850	4.75	160,000	32,000
1½	5.20	156,600	43,500	4.68	148,500	41,250	5.70	190,000	38,000
1⅝	6.20	198,000	55,000	....	.....	.....	.....	.....	.....
1¾	....	.....	.....	....	.....	.....	7.65	258,000	52,000
2	....	.....	.....	....	.....	.....	10.00	340,000	68,000
2¼	....	.....	.....	....	.....	.....	12.50	440,000	88,000
2½	....	.....	.....	....	.....	.....	15.50	550,000	110,000
Factor of safety			3.6	....	.....	3.6	.....	.....	5.0

Deflection Due to One Concentrated Load

One load at any point:

$$H = (ws + 2g)\frac{mn}{2st}$$

One load at center:

$$H = (ws + 2g)\frac{s}{8t}$$

One load at distance y from one end:

$$H = (wms + 2gy)\frac{n}{2st}$$

Empty Cable; Chord Inclined

Let Fig. 3 represent such a case, l being length of chord:

$$\text{Deflection at center: } h = \frac{ws}{8t \cos a}$$

$$\text{Deflection at any point: } h_1 = \frac{wmn}{2t \cos a}$$

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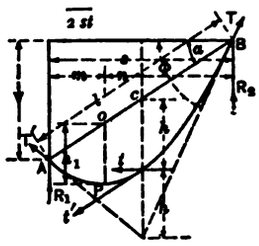

Fig. 3

Cable Carrying Concentrated Loads; Chord Inclined

Load at any point of an inclined span:

$$\text{Deflection } H = (wl + 2g)\frac{mn}{2ts}$$

Load at center:

$$H = (wl + 2g)\frac{s}{8t}$$

Load at distance y from one end:

$$H = (wml + 2gy)\frac{n}{2ts}$$

Length of Parabolic Curve

The length of a symmetrical parabolic curve L, when the rise is small, is closely approximate:

$$L = S + \frac{Sh^2}{3s}, \text{ or } h^2 = \frac{3}{8}s\,(L - s)$$

If the chord be inclined, the length, for taut curves common in tramway practice may be taken as equivalent to a symmetrical parabola having same chord length and same deflection normal to the chord. The normal deflection is nearly equal to vertical deflection $\times$ cos a.

Horizontal Tension (t)

In tramway construction, cables are stretched by tension applied to one end of the span (usually by a weight), equal to working tension of the cable. This tension is used in formulas for the value of t; it makes the actual horizontal tension in cables a little less than that used in the calculations, and hence the sag will be a little greater than calculated. Owing to the flatness of the curves, this error is not serious, when the chord is at a low angle. But on inclined spans it may make considerable difference; the error can be partly compensated by calling the applied tension t′, and assuming that its direction is parallel to inclined chord; then the approximate horizontal tension, to be used in the formulas, will be $t = t' \cos a$.

OPERATING FORMULAS

Spacing of Carriers

For a system operating a continuous series of carriers, let:

t = time interval between carriers, sec.
d = distance between carriers, ft.
l = load in one carrier, lb.
n = number of tons to be carried per hr.
v = velocity of tramway, ft. per min.

Then

$t = 1.8l \div n.$
$d = 0.03\,lv \div n.$

Tension in Traction Rope

Tension in a rope holding any body at rest on an incline, neglecting friction, is $T = W \sin a$. Friction of a body moving on an incline is, $F = fW \cos a$; in which,

T = tension parallel to the plane, in same unit as W.
W = total weight of bodies on plane, preferably in lb.
a = inclination of plane.
f = coefficient of friction.
F = total friction, in same unit as W.

Where the body extends the whole length of the incline, as a rope lying on it, then the total weight is $W = wL$, where

w = weight per ft., in same unit as W.
L = inclined length of the plane, ft.

Then

$T = wL \sin a = wV.$
$F = fwL \cos a = fwH.$

in which

V = vertical distance between ends of plane.
H = horizontal length of plane.

Tension in traction rope of a double rope tramway, or an endless rope of a single rope tramway, at its upper end, taking friction into account, will be:

$T = wV \pm fwH.$

Transmission of Power by Band Drives

In a band drive, tension on the slack side must bear a certain relation to tension on the taut side to develop sufficient friction to prevent slipping. The formula for this relation is:

$T = Se^{f\,3.1416\,n}$

in which:

T = tension on taut side, S = tension on slack side } Both in the same unit, preferably lb.
e = base of Naperian logarithms = 2.71828.
f = coefficient of friction (see accompanying Table).
n = number of half laps on drum (number of turns of 180° each).

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The useful effect, or force transmitted by the drive, is the difference between tensions on the two sides, that T — S.

Therefore

$$T - S = S(e^{f\,3.1416\,n} - 1)$$

which is an expression for the force transmitted by a band drive.

Coefficients of Friction, f, for Band Drives

Condition of Surfaces	Iron on Iron	Iron on Wood	Iron on Rubber or Leather
Dry	0.170	0.235	0.495
Wet	0.085	0.170	0.400
Greasy	0.070	0.140	0.205

Values of $e^{f\,3.1416\,n}$

f	n = Number of Half Laps About Sheaves or Drums					
	1	2	3	4	5	6
0.070	1.246	1.552	1.934	2.410	3.003	3.741
0.085	1.306	1.706	2.228	2.910	3.801	4.964
0.100	1.369	1.875	2.566	3.514	4.810	6.586
0.120	1.458	2.125	3.099	4.518	6.586	9.602
0.130	1.504	2.263	3.405	5.122	7.706	11.593
0.140	1.552	2.410	3.741	5.808	9.017	13.998
0.150	1.602	2.566	4.111	6.586	10.551	16.902
0.170	1.706	2.910	4.964	8.467	14.445	24.641
0.200	1.875	3.514	6.586	12.346	23.140	43.376
0.205	1.904	3.626	6.904	13.146	25.031	47.663
0.235	2.092	4.378	9.160	19.166	40.100	83.902
0.250	2.193	4.810	10.551	23.140	50.637	111.318
0.265	2.299	5.286	12.153	27.941	64.239	147.693
0.300	2.566	6.586	16.902	43.376	111.318	285.680
0.350	3.001	9.017	27.077	81.307	244.152	733.145
0.400	3.514	12.346	43.376	152.405	535.488	1,849.140
0.410	3.626	13.146	47.663	172.814	626.577	2,271.775
0.450	4.111	16.902	69.487	285.680	1,174.480	4,828.510
0.495	4.716	22.425	106.194	502.881	2,381.400	....
0.500	4.810	23.140	111.318	535.488	2,575.940	....

DESIGN OF CABLEWAYS

Data required are: (1) plan and cross-sections, or contours, of volume to be excavated, the sections showing probable maximum depth of excavation; (2) position and elevation of discharge points; (3) kind, size, and weight per piece, or per cu. ft., of material to be handled; (4) quantity to be handled in tons per hr.; (5) nature of power to be used.

Weight of Load

Is sometimes governed by size of individual unit or pieces. In stripping it is usually determined by quantity of loose material to be handled per hr., although weight of single blocks of stone may be the controlling factor. Net loads equal tonnage per hr., divided by number of loads that can be handled per hr.

Time Per Load

Is made up of time to hoist, transport load, dump it, return the skip to pit, and change connections to another load. Speed of hoisting and lowering may be as high as 300 ft. per min. Carriage can be hauled along cable at 1000 to 1500 ft. per min., with button-spaced fall rope carriers, and at about 800 ft. per min., with chain-spaced fall rope carriers. Maximum distance to be hauled may be taken as 80% of span; it can rarely exceed 90%, and is not likely to exceed 70% for any length of time.

Size of Cable

This depends on load, span, and allowable deflection. In beginning a design it is usual to allow a deflection of 0.05 of span, when load is at center.

Typical Cableways

The largest loads that have been carried are 37 tons on a pair of cables and 20 tons on a single cable, on twin cableways of Great Western Power Company, Feather River, Cal.; span 1140 ft. Several cableways have been built to carry 15-ton loads.

GENERAL SPECIFICATIONS FOR CABLEWAYS

Load, tons	Cables, diam., in.	Operating ropes, diam., in.	Engine, 2 cyls., in.	Carriage and fall block, approx. wt., lb.
1	1.25	½	8x10	600
2	1.5	⅝	8x10	1000
4	1.75	⅝	10x12	1600
6	2	¾	10x12	2000
8	2.25	⅞	12x15	2300
10	2.5	⅞	12x15	2500

Cableways

Are frequently used in quarry work, canal and trench excavation, and in open pit mining. Chicago Drainage Canal employed 19 cableways with spans of 550 to 725 ft., traveling towers 73 to 93 ft. high, and equipped with aerial

TYPICAL SPECIFICATIONS

Span, ft.	Load, tons	Cable diam., inches	Operation rope, inches	Hoister, size	Remarks
800	1	1.5	⅝	8¼x10	Hoisting speed, 200 ft. per min. Traversing speed, 800 ft. per min.
300	2	1.5	⅝	8½x10	
950	5	2	¾	10x12	Head tower, 95 ft. fixed; tail tower, 35 ft., movable; capacity 750 tons limestone per day.
500	5	2.25	⅝	50 H. P. electric	Towers travel. Hoisting speed, 233 ft. per min.; traversing speed, 700 ft.
700	8 or 5 cu. ft. rock	2.25	..	10x12	Chicago Drainage Canal, 17 cableways. Towers travel; head, 92 ft. high on 44x108 ft. car; tail, 72 ft. high on 37x82 ft. car.
1200	4	2.25	⅝	110 H. P. electric	Towers, 160 ft.
1350	7	2.5	¾	10x12	Towers, 30 and 70 ft. high. Handles 180 cu. ft. per day.
900	7	2.25	¾	11x14	2 cableways. Towers, 80 ft. high. Each handles 400 tons per 10 hrs.
800	6	2.25	..	150 H. P. electric	Panama Canal. 8 cableways. Towers, 85 ft. high, steel, movable. Deflection of cable, 44 ft. Hoisting speed, 333 ft.; traversing, 1800-2000 ft.
1420	10–15	....	..	300 H. P. electric	3 cableways.
1500	12	2.25	..	12x12 and 12¼x15	4 cableways. Towers movable. Engines use compressed air at 90 lb. Each handles 236 skips, 8x8x2 ft. 4 cu. yds. excavated material, place measure; or 226 batches, 2.5 cu. yds. each of concrete; or 622 cu. yds. stone block, per 8 hrs.

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dumps. Main cables, 2.25 in., hauling and hoisting cables, 0.75 in., button and dumping cables, 5/8 in. They had a hoisting speed of 250 ft. and a traveling speed of 1000 ft. per min. Arrowrock Dam, Idaho, had two cableways which handled 101,263 cu. yds. of blasted rock, boulders, gravel and sand. Span, 1300 ft.; average traveling distance, 500 ft.; average hoisting distance, 300 ft. Hoisting load, 8 tons, at 300 ft. per min.; conveying speed, 1200 ft. per min. Skips, 8 by 8 by 2 ft. Canal work on St. Mary's Channel Improvement, 2 cableways handled 1,700,000 cu. yds. of limestone in 2.5 years. Rock was loaded into skip by four 60-ton traction-mounted steam shovels. Skips held 6 cu. yds. each, but sometimes 8 cu. yds. (18 tons) were handled. Two cableways had spans of 1100 ft. and 2 of 800 ft. Average haul, 300 ft. Best month's record for all, 22,000 cu. yds. each; best month's record for one cableway, 30,000 cu. yds.

OUTPUT OF FOUR CHICAGO DRAINAGE CABLEWAYS (ONE MONTH)

	1	2	3	4
No. of 10-hr. shifts	49	35	52	49
Total cu. yds, rock	12,633	8,632	16,162	14,535
No. of skip-loads, day shift	5,111	5,327	5,435	4,369
No. of skip-loads, night shift	4,087	1,201	5,467	4,468
Cu. yds. solid rock per skip	1.44	1.32	1.48	1.65
Cu. yds. solid rock per shift	258	247	311	297
No. of laborers	27	27	32	32
No. of foremen	2	2	2	2
Total labor, hrs	12,861	9,608	17,075	15,227
Cu. yds. rock loaded per man per shift	9.82	8.98	9.46	9.54
Tons coal per shift	1.83	1.83	2.28	2.28

DOUBLE-ROPE TRAMWAYS—Continuous System

Elements

A double-rope tramway consists of: (1) two track cables stretched at required tension; (2) an endless traction rope for moving the loads; (3) numerous carriers for the loads, each fitted with carriage or trolley to run on track cable and a clamp or grip for seizing traction rope; (4) a station at each end to operate or control the traction rope and provide places for loading and unloading carriers; (5) intermediate towers for supporting track cable and traction rope.

Capacity

Economical limits of capacity for double-rope tramways are approximately 10 tons per hr. as minimum and 150 tons per hr. as maximum. If less than 10 tons per hr. are to be carried it is more economical to operate the tramway fewer hours or on alternate days, than to reduce its carrying capacity. A traffic of 150 tons per hr. requires quite heavy loads at frequent intervals, and represents the maximum that track cable will stand without excessive wear.

Length

It is seldom wise to use double-rope tramways for distances less than 1000 ft., because terminal machinery costs as much as for a longer line and so makes first cost excessive. Maximum limit, under favorable conditions, is about nine miles; the resulting 18 miles of traction rope being as long as can be operated successfully. If distance be greater, a series of tandem tramways can be built.

Loads

Net weights of 500 and 1500 lbs. are the usual lower and upper limits for loads on ordinary tramways; below 500 lbs. there is no saving in cost of carriers, and over 1500 lbs. the wear on cables is great. The time intervals between carriers is conveniently 1/2 min. Tramway speeds have constantly increased. Speed must be high to carry a large tonnage without increasing weight of moving parts, or stresses due to their weights, but when speed is too high it is difficult to handle the carriers at the terminals. The practical speed is about 8 ft. per sec., with 10 ft. per sec. as maximum with favorable conditions and careful designing.

Towers

The location and height of towers must be such that: (1) track cable will lie firmly in the saddles under all conditions of loading; (2) the angle made by cable over any saddle at a crest will not be excessive. The tops of towers are brought up to a construction curve, the tension of which is 1.5 times the working tension of track cable. The deflection angle made by empty cable over any saddle shall not exceed 2° 52′. On long spans, the loaded position of the cable should be calculated and plotted, and its relation to towers and ground investigated.

Construction at Crests

This is a difficult problem. The principal wear on track cable occurs near towers, and this is aggravated at crests by downward pressure due to pull of traction rope, added to the weight of carrier. Downward pressure is minimized by making the curve over the crest as easy as possible, by introducing a series of towers at short intervals and distributing the bend among them.

RELATIONS OF CABLE SIZES, LOADS, ETC., TO TONNAGE

Tons per hr.	Diam. of Cables, Inches		Net Loads, Lbs.	Gage, Ft.	Style of Carriage
	Loaded Side	Empty Side			
5 to 10	1	7/8	500	6	Light
15 to 20	1 1/8	7/8	600	6	Light
25 to 30	1 1/4	7/8	800	6 or 8	Heavy
40 to 50	1 3/8	7/8	1,200	8	Heavy
60 to 75	1 1/2	1	1,500	8	Extra heavy
80 to 100	1 5/8	1	2,000	8 or 10	Extra heavy

RADIUS OF CURVES THROUGH TOWERS

Deflection	Tangent	Angle a	Cosec. 1/2 a.	Spacing of Towers, Measured on the Curve									
				10	20	30	40	50	60	70	80	90	100
1/2 :20	0.025	1°-26′	79.95	400	800	1200	1600	2000	2400	2800	3200	3600	4000
3/4 :20	0.0375	2°-09′	53.81	270	540	810	1080	1350	1620	1890	2160	2430	2700
1 :20	0.05	2°-52′	39.98	200	400	600	800	1000	1200	1400	1600	1800	2000
1 1/4 :20	0.0625	3°-34′	32.13	160	320	480	640	800	960	1120	1280	1440	1600
1 1/2 :20	0.075	4°-18′	26.66	133	267	400	533	667	800	933	1067	1200	1333
1 3/4 :20	0.0875	5°-00′	22.93	115	230	345	460	575	690	805	920	1035	1150
2 :20	0.10	5°-42′	20.11	100	200	300	400	500	600	700	800	900	1000

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AMERICAN STEEL & WIRE CO.

SALES OFFICES

CHICAGO.....208 So. La Salle Street
NEW YORK.....30 Church Street
WORCESTER.....94 Grove Street
BOSTON.....185 Franklin Street
PHILADELPHIA.....Widener Building
PITTSBURGH.....Frick Building
BUFFALO.....337 Washington Street
DETROIT.....Foot of First Street
CINCINNATI.....Union Trust Building
CLEVELAND.....Western Reserve Building
BALTIMORE.....32 So. Charles Street
WILKES-BARRE, PA.....Miners Bank Building
ST. LOUIS..Liberty Central Trust Company Bldg.
KANSAS CITY.....417 Grand Avenue
ST. PAUL-MINNEAPOLIS.Pioneer Bldg., St. Paul
OKLAHOMA CITY...1st National Bank Building
BIRMINGHAM, ALA.....Brown-Marx Building
DENVER.....1st National Bank Building
SALT LAKE CITY.....Walker Bank Building

Export Representatives: U. S. Steel Products Co., New York
Pacific Coast Representative: U. S. Steel Products Company
San Francisco Los Angeles Portland Seattle

AERIAL TRAMWAYS

Products

Aerial Tramways, Wires and Cables in the following materials: Iron; Crucible Cast Steel; Extra Strong Crucible Cast Steel; Plow Steel; Monitor Steel.

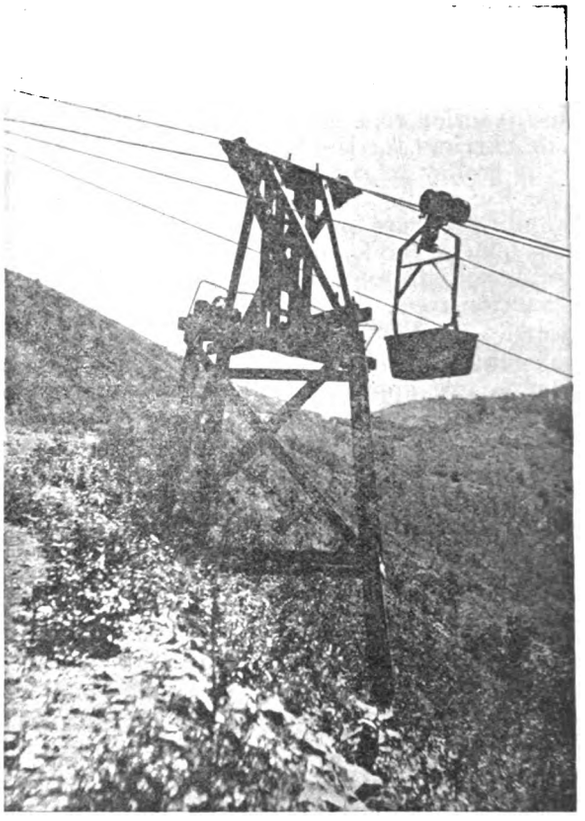
Wire Rope Fittings and Accessories, including Thimbles, Clips, Clamps, Sockets, Hooks, Shackles, Turnbuckles, Blocks, Sheaves. See pages 416 to 421.

Electrical Wires and Cables, including Copper Trolley Wire; Hard Drawn Copper Telegraph and Telephone Wire; Magnet Wire; Annunciator Wire; Office Wire; Weatherproof Wires and Cables; Slow Burning Wires and Cables; Lamp Cords; Electric Heater Cord; Rubber Covered Wire for Interior Wiring; Feeder Cables; Switchboard Cables; Rubber Covered Fireproof Cables; Duplex and Concentric Cables; Fixture Wire; High Voltage Cables; Lead Encased Cables for Lighting and Power; Galvanized Telephone and Telegraph Wire, see pages 266 to 269; Rail Bonds, see page 335.

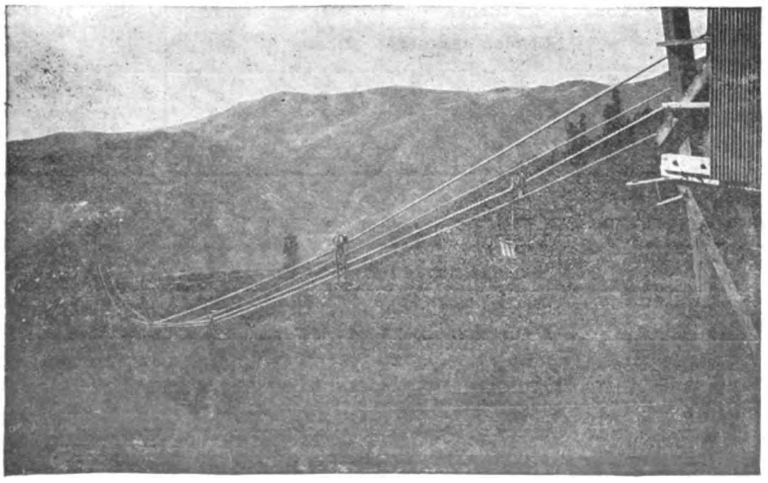
Everything in the Wire and Cable line.

Trenton Aerial Tramways

A system of transportation by which the material is carried in receptacles suspended from carriages running on stationary track cables. A separate endless haulage rope, to which the carriers are attached, controls their motion.



Ore Carrier Passing Tramway Tower



Trenton Tramway Conveying Ore in Mountainous Country

Application

Aerial wire rope tramways are used for conveying coal, ore, lumber, merchandise, agricultural products, passengers, etc. Special types of lines are highly efficient and economical for waste disposal or for piling materials for storage.

Aerial conveying often is the only means of bringing mine or quarry products to plant or railroad. Mountainous country or intervening rivers are readily crossed by the shortest direct route and without the necessity of tunnels, cuts or fills, or bridges. Storms of snow or rain which would disrupt surface haulage do not hinder the continuous operation of an aerial tramway.

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Trenton Tramways provide the most economical transportation.

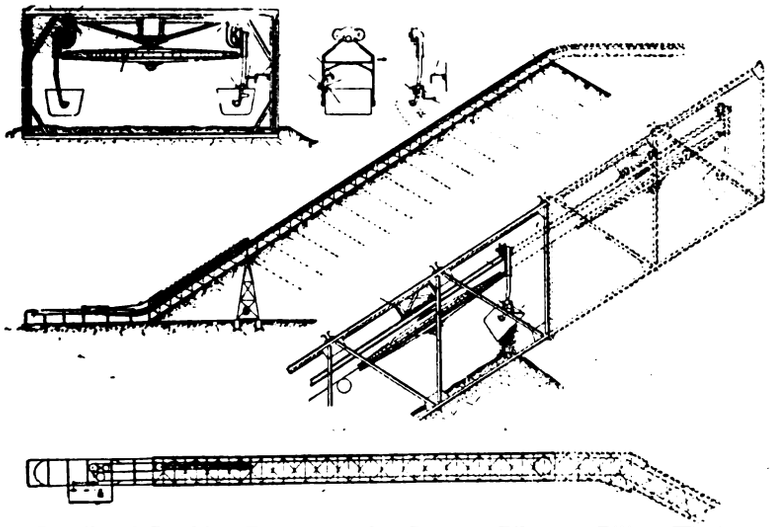
Our designs and mechanical details are based on the experience of over 35 years of tramway manufacturing. Any material can be carried, any distance or in any quantity.

sheaves, shafts, bearings, gears for power connection, rope guides, saddle rollers, automatic attachers and detachers; machinery bolts and washers, timber bolts, anchorage irons, braking mechanism, telephones, reverse preventers, speed indicators, etc., as may be necessary or advisable.

Trenton Tramway for Disposal of Mine Waste. Showing Waste Piled by Aerial Dumping of Bucket.

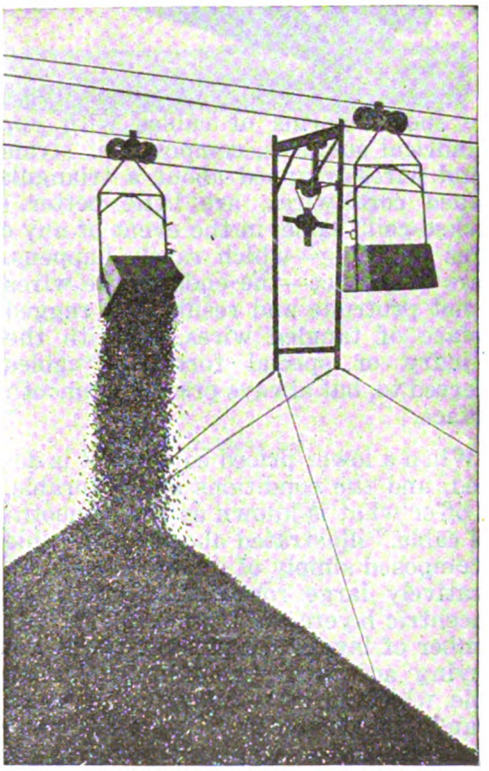
Engineering and Construction

We design complete aerial tramway installations, furnishing detailed working drawings of the tramway terminals and intermediate structures.



Details of Stacking Tramways, for Storage Piles or Piling Waste

We furnish all mechanical equipment or metal parts required, including track cables and traction rope (with tools for installing them), terminal rail and accessories, terminal machinery, including



Self-Dumping Bucket Discharging Contents Upon Passing Through Automatic Movable Tripping Frame

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Track Cables

The track cables recommended in the aerial tramways built by the American Steel & Wire Company are known as the Trenton "locked-coil cables," so named from the fact that the outer wires which are drawn to shape, interlock one with the other, as illustrated in Figure 1. The smooth

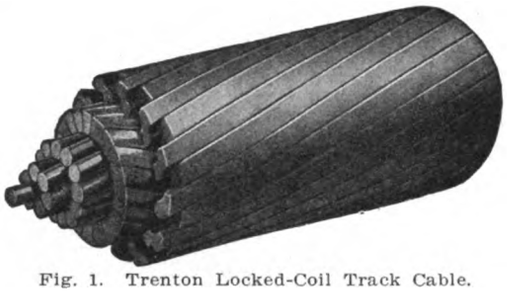
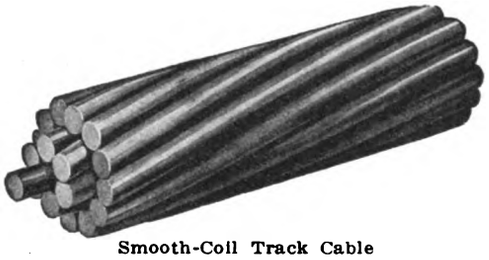


Fig. 1. Trenton Locked-Coil Track Cable.

surface of this cable results in a uniform distribution of wear not obtained in any other kind of cable, which adds to the life not only of the cable itself, but also to the carriage wheels which traverse it. This cable is made in lengths varying from 800 to 1,500 feet, and owing to its peculiar construction, is quite stiff, but sufficiently flexible to be shipped in coils from 5 to 6 feet in diameter.

Wire cable of the ordinary construction, composed of round wire strands, laid about a hemp or wire strand core, is not at all adapted to this purpose, on account of the comparatively small wires under the constant traction of the carriage wheels.



Smooth-Coil Track Cable

The special forms of cables with approximately cylindrical surfaces, composed of strands made of round wires wrapped about a triangular or other shaped core wires, are little better. With the "locked-coil" cable, in the event of any of the outer wires breaking—which rarely happens until after years of service—the ends of the wires do not protrude and result in a ragged surface of tangled wires, as with the ordinary or special forms of cables referred to, but always present a smooth surface.

When a lower-priced equipment is desired, and the conditions are favorable, we offer what is known as the "smooth-coil cable," illustrated above. This cable is composed simply of a number of comparatively large round wires coiled in concentric layers about a core wire, the number of layers and sizes of the wires varying according to the size of the cable, which is, in reality, simply a large strand, the surface of which when new, resembles that of a spirally-fluted cylinder, and when worn, approximates that of a smooth round bar.

The smooth-coil cable is more durable than the track cables offered by other makers at the same price, made of smaller wires, and barring the locked-coil cable, is unsurpassed as a track cable in its wearing qualifications.

Rolling Stock

The ordinary carrier for transporting ore and like material consists of a carriage that traverses the track cables, from which is pivoted in suspension a hanger that supports the bucket or other receptacle, and above which is a grip by means of which attachment to the traction rope is effected.

The loading and discharge of the receptacles at either terminal or intermediate stations can be effected at any point or any number of points.

The steepest grades can be surmounted without difficulty.

Less power is required, or more developed, as the case may be, than with any other system.

The carriers, if necessary, can be run around angles without requiring the services of an attendant.

The carriers can also be run around either terminal, where no loading or discharge of the receptacles occurs, without requiring the services of an attendant.

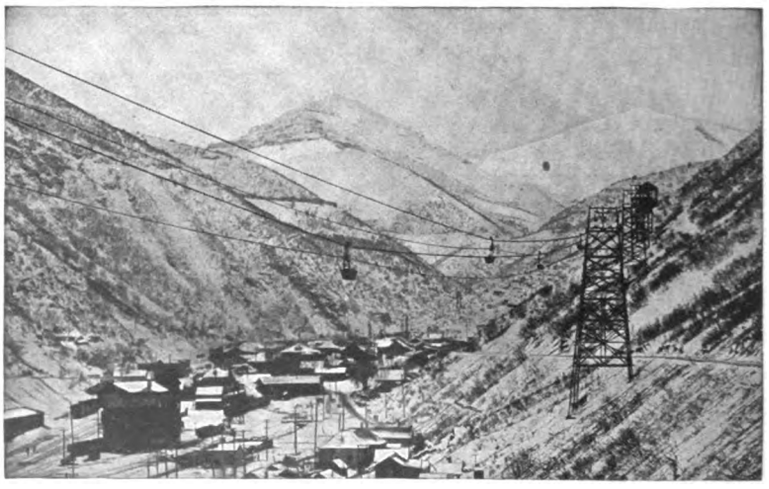
Low cost of maintenance and operation.

A wide variety of receptacles can be furnished, the style depending on the material to be carried.

The illustration is that of a Self-Dumping Bucket, with Automatic Overhead Grip.

Self-Dumping Bucket

The construction of the Trenton Automatic Overhead Grip is such that the weight of the carrier acts as the gripping force. This construction possesses the advantage of being independent of any nice adjustment of the grip jaws, so that the grip automatically accommodates itself to irregularities in the wear of the traction rope.



Tramway, Showing Portion of 750-Foot Span and 90-Foot Support. Length of Line, 12,270 Feet. Hourly Capacity, 60 Tons.

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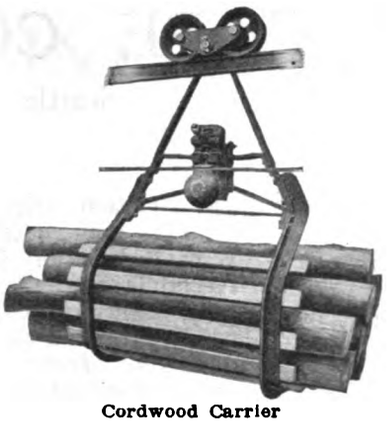
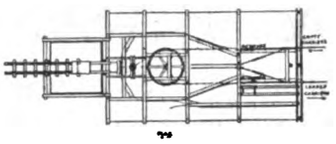
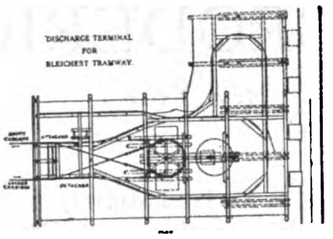
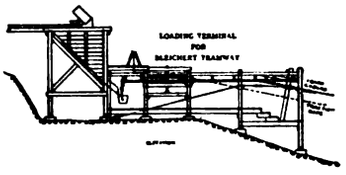
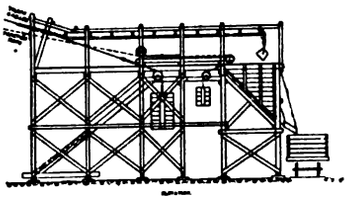


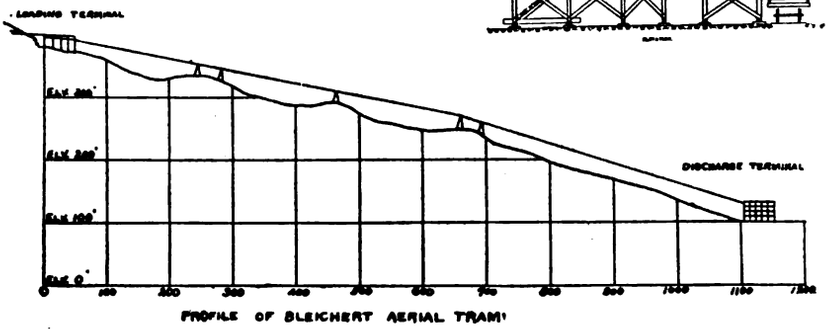
Cordwood Carrier











Data for Estimating

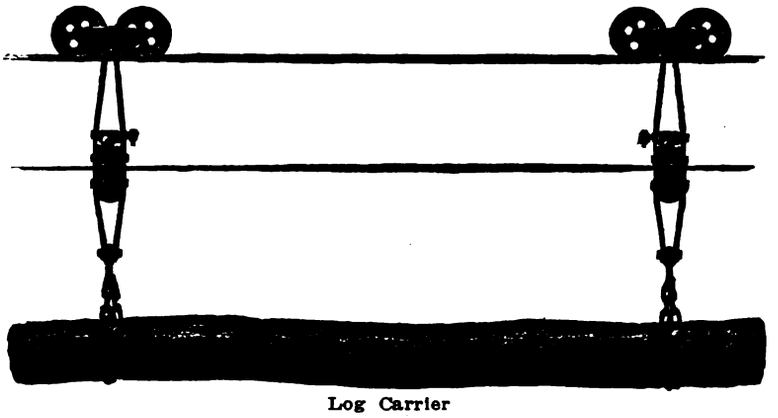
Estimates and suggestions will be furnished freely on application. Prospective buyers should submit the following data, which is essential for the proper consideration of their problem by our engineers:

Describe the purpose of the proposed installation, naming the material to be handled, its weight (or dimensions, if packages) in pounds per cubic foot, as loaded in the tramway receptacles, and the quantity to be transported hourly.

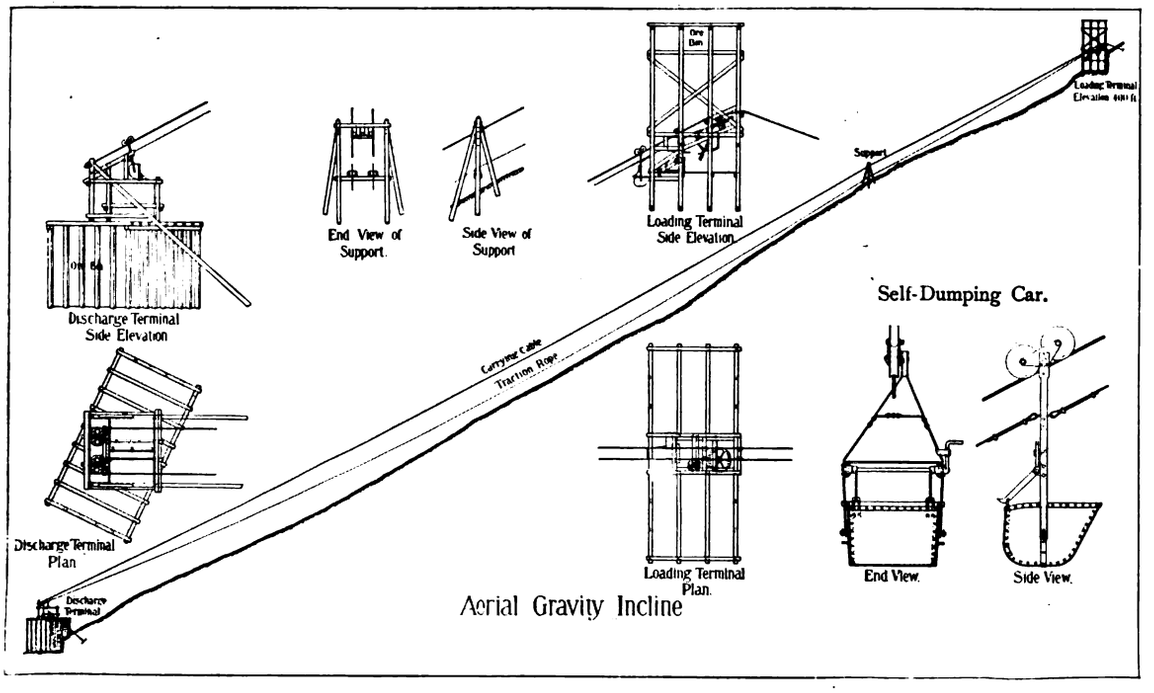
Describe the ground over which the tramway will be built, giving distance between loading and discharging points, difference in elevation, and data covering rivers, railroads, highway or buildings to be crossed.

Definite estimates can be prepared only upon receipt of an accurate profile along the center line showing elevations and horizontal distances.

Preliminary estimates will be furnished upon receipt of general information outlined above.



Log Carrier



Aerial Gravity Incline

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BRODERICK & BASCOM ROPE CO.

New York Main Office, ST. LOUIS Seattle

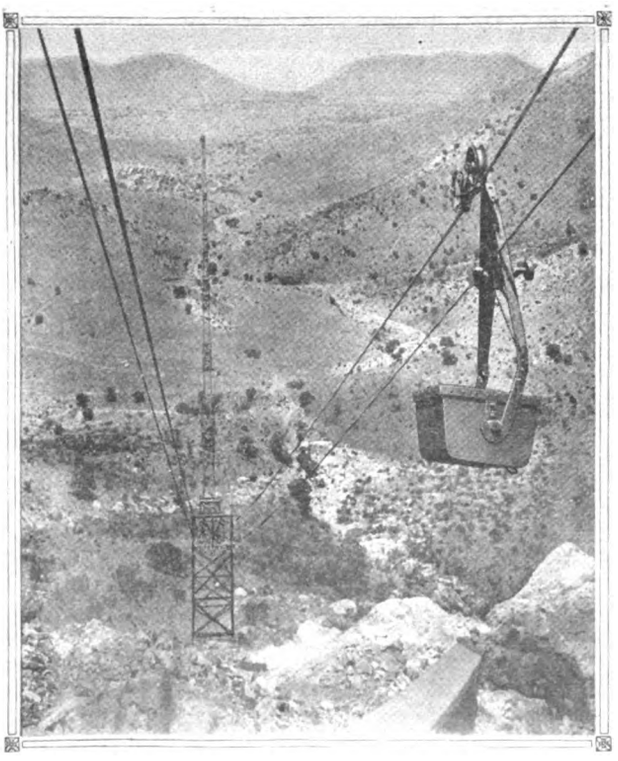
Factories: St. Louis and Seattle

B & B Aerial Tramways

Make haulage of ore, coal and like materials absolutely independent of weather and road conditions, and of all peculiarities in the contour of the ground. They are economical in operation, saving time and labor. Where the fall is sufficient, they operate entirely by gravity, otherwise steam, gasoline or electricity may be employed.

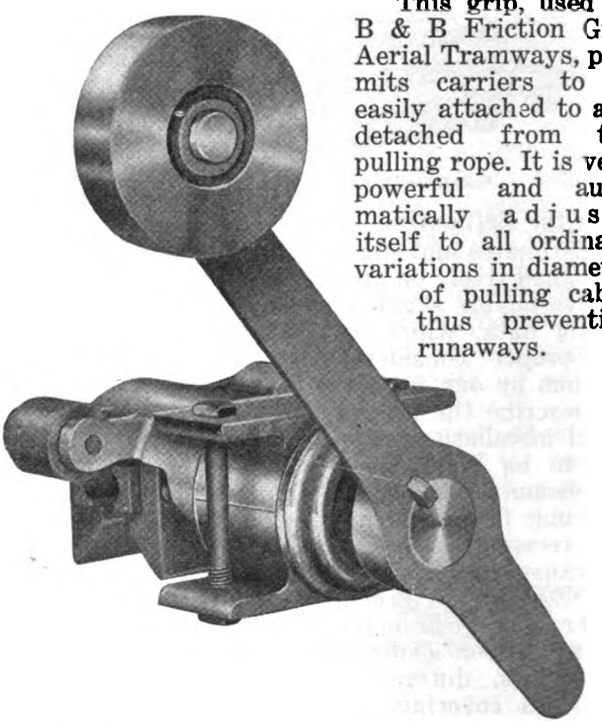
For long distance haulage the B & B Friction Grip System is recommended. The capacity can be regulated to suit requirements.

For shorter distances the B & B Two-Bucket System is ideal. Only one man is required for the operation of this system.



Patented Improved Screw Type Friction Grip

This grip, used on B & B Friction Grip Aerial Tramways, permits carriers to be easily attached to and detached from the pulling rope. It is very powerful and automatically adjusts itself to all ordinary variations in diameter of pulling cable, thus preventing runaways.



The Grip is steel throughout, accurately machined, with interchangeable parts. Wearing surfaces heat treated and hardened, insuring long service.

Every B & B Tramway is especially designed to suit the individual requirements of each proposition. Satisfactory operation guaranteed.

Catalog and complete estimates gladly furnished upon request.

We are also the manufacturers of the celebrated "Yellow Strand" and all standard grades of wire rope.

"Yellow Strand Powersteel" Wire Rope is absolutely trustworthy for heaviest hoisting, cableways, steam shovels and other mining uses. It is made of steel wire drawn exclusively for Yellow Strand. No wires are subjected to stricter tests before acceptance. No cable, we believe, could have greater tensile strength, except at the sacrifice of elasticity, toughness, and resistance to torsions.

Write for complete Wire Rope Catalog and prices.

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INTERSTATE EQUIPMENT CORP.

25 Church Street, NEW YORK

AUTOMATIC AERIAL TRAMWAYS

(Lawson System)

The mine operator is frequently confronted with problems in the moving of materials, the solution of which determine the difference between success and failure of his project.

By employment of a system of aerial hauling many a property otherwise valueless may be converted into a paying producer.

The efficiency and economy of the automatic aerial, double-track system has been proven by a variety of installations where it has been employed to meet otherwise impossible conditions.

In the matter of capacity, distance of haul, and country to be traversed, it may be installed so as to meet the special requirements of any case.

The only double-track system with four-wheeled cars running above cables instead of being underslung.

It is an air route for economic hauling.

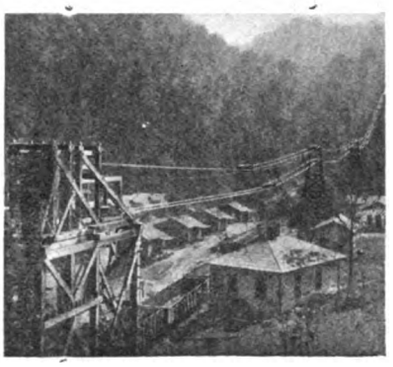
Low Initial Cost. Low Operating Cost. Low Depreciation Charge.

Loads and unloads automatically. Simple in design and construction. Operates continuously regardless of weather.

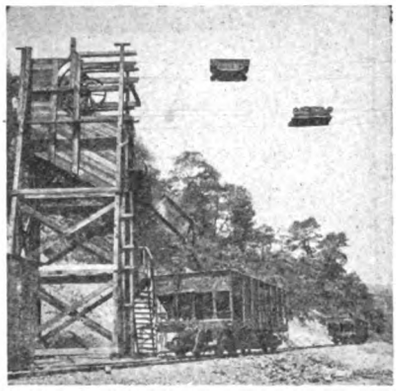
Send for estimates which will be furnished by our Engineering Department on receipt of specifications covering requirements.

A FEW TYPICAL FEATURES OF THE AUTOMATIC SYSTEM

Discharge terminal and supporting tower for barytes mine. Hauls barytes to railroad and coal to mine.



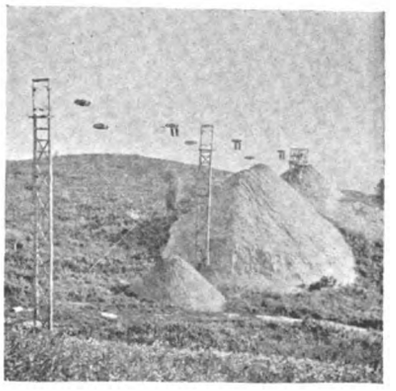
Hauling coal down steep grade, spanning river and mine settlement.



Automatic discharge terminal. Coal delivered direct to railroad car.

Hauling crushed stone for silica brick plant. Discharging into storage bin inside building.

Inexpensive but substantial construction. All-steel cars strongly reinforced.



Illustrating method employed for automatic discharge of loads at any point between terminals accomplished by use of bottom dump cars.

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SECTION XIV

Placer, Hydraulic and Dredging

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

American Spiral Pipe Works
Continental Pipe Manufacturing Co.
Hendy, Joshua, Iron Works
Pacific Lumber Co., The

FOR LIST OF EQUIPMENT USE D IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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SIMPLE METHODS OF MAKING DITCH SURVEYS*

By JAMES W. PHILLIPS

The first miners were gravel-miners. They put in ditches to carry the required water, though few, if any, knew how to figure the flow of water. A crude method of measuring water flowing through orifices under a head was developed, and the amount of water was the area in square inches of the orifice, regardless of its shape. The gravel-miner wanted to get water to the place where it was needed, and the possibility of washing the ground away was the only thing that prevented him from running his ditches in a straight line if possible, instead of following a grade. In many instances tunnels were cut and straight flumes put across valleys. Following the first miners, and practically at the commencement of the hydraulic-mining era, there followed a generation of men, many of them surveyors and engineers, who used the following adaptation of the Eytelwein formula for open ditches:

$$v = \sqrt{(9000\ rs + 0.012)} - 0.11$$

or the following adaptation of the Poncelot formula

$$v = \sqrt{\left(\frac{9000\ as}{p}\right)} - 0.11$$

and for pipes the following adaptations of the Hawksley and Poncelot formulas:

$$v = 48\sqrt{\frac{dh}{L + 54d}}$$

in which v = mean velocity in feet per second; a = area of cross-section of water, in feet; p = wetted perimeter in feet; r = hydraulic mean radius in feet = a ÷ p; s = sine of slope = h ÷ L; h = fall in feet in any length; L = total length in feet on the slope; d = diameter of pipe in feet.

The foregoing formulas were printed in many handbooks given away by firms dealing in tools and machinery used by miners, and also in miners' pocket-books. They seldom appeared, however, in the forms here given, but were painfully expressed in words like rules in arithmetic, with worked-out examples. They were used by a great many men who would have been scared by the sight of a formula. A tremendous amount of practical data has been stored in the heads and notebooks of the older miners, but the engineer of experience in this line of work is better equipped than the practical man without scientific education.

As the mines grew larger, and the operations were conducted on a mammoth scale, the engineer was employed to run the ditch-lines and do all the work that called for education and skill in the handling of water. When the larger mines were finally shut down by the court, a large number of engineers had to seek other employment, and many of them engaged in irrigation, but found it hard to come down from grades of 10 ft. to the mile to that many inches sometimes. The classic experiments of Hamilton Smith on the flow of water in pipes were made for hydraulic miners, and the engineers employed from early in the '70s to the time the work was stopped were men of whom the State might well be proud, and were a credit to their great profession. With the engineers employed by the larger companies, as with the engineers employed today, the favored formula has been the Chezy; that is,

$$v = C\sqrt{rs}$$

with the factor C computed by the Kutter formula, or the following modification of it, which is close enough for practically all use:

$$C = \frac{42 + \frac{2}{n}}{1 + \frac{42n}{\sqrt{r}}}$$

using the following values of n: planed boards, n = 0.010; common boards, n = 0.012; rubble, n = 0.017; earth, n = 0.025.

In surveying for a line, flumes and abrupt turns should be avoided wherever possible. It is always well to hit a hill hard in going around a point, so there will be a good outer embankment. There will be a good roadway along all ditches, and on the lower side all obstructions, bushes, etc., should be removed in order that the lower bank, made by fill, will be solid. A number of hints might be given, but they are all summed up by saying that the ditch should be in as firm ground as possible and constructed so it will not destroy itself.

Many of the older generations of miners have damaged the appearance of much of the country because of the steep grades on their ditches, and many abandoned ditches have become ravines. The modern engineer and ditch-builder pays some attention to the character of the material through which the ditch runs. Careful attention to the following table of safe velocities, given by Sir John Neville in his Hydraulic Tables, is recommended for mean velocities:

0.42	feet	per	second	in soft alluvial deposits.
0.67	"	"	"	" clayey soils.
1.00	"	"	"	" sandy and silty beds.
2.00	"	"	"	" gravelly earth.
3.00	"	"	"	" strong gravelly shingle.
4.00	"	"	"	" shingly soil.
5.00	"	"	"	" shingly and rocky soil.
6.67	"	"	"	and over, in rock.

A limit of about 15 ft. per sec. is set for first-class masonry and wood, the bottom velocity being about two-thirds to three-quarters the mean velocity. The

*Abstract from Hydraulic Mining of Auriferous Gravels. Journ. West Soc. Engineers, August, 1910.

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Dubuat formula for bottom velocity is as follows:

$$v_b = v\ 11\ \sqrt{rs}$$

in which v_b = bottom velocity in feet per second; v = mean velocity in feet per second; r = mean hydraulic radius; s = sine of the slope.

In the reconstruction of these old ditches to meet the requirements of hydraulic mining, I have always maintained that careful observance of the character of the material through which the ditch runs, and a careful stepping down of the grade at intervals of from one-eighth to one-fourth of a mile, would reduce the initial cost of construction as well as of maintenance. Throughout this section a grade of 6 to 12 ft. to the mile is as much as should be used.

The pioneer miners were a resourceful body of men, and many difficult problems were solved by them in the construction of their tunnels, ditches, and other engineering works of magnitude. Miles of ditch-grades were run with only a buckskin thong with a rock tied to it for a plummet, attached to the apex of an A-frame made of three small spruce poles. I remember, when, as a lad of eight years of age, I drove grade-pegs upon a ditch-survey run by my father, assisted by my brother, through five miles of the roughest country in northern California, with one of these "instruments of precision", and how in veneration I stood upon the brink of a deep canyon, the precipitous sides of which precluded a measurement with chain or tape, and witnessed the chief of party triangulate the distance across with accuracy and dispatch, and establish the grade with this simple contrivance with as much ease as the present day engineer would accomplish it with his transit and stadia, or with the gradienter attachment.

The A-frame is made as follows:

Construct with any light material an A-frame with the legs extending 2 ft. below the cross-bar, and having a span of from 10 to 12 ft.; at the apex drive a nail and hang a plumb-bob from it with line sufficient to permit the plumb-bob to hang below the cross-bar. This instrument is adjusted over two pegs as follows: Drive two pegs in the ground at a distance apart equal to the distance spanned by the legs of the frame; place the frame upon the pegs and note the position of the plumb-line at the cross-bar; reverse the frame and note the second position of the plumb-line between the two positions already noted, and drive the highest peg down until the plumb-line covers this midway mark on the cross-bar; the tops of the two pegs will then be at the same elevation. Several methods are used for graduating the cross-bar to permit of grades being run, and one method is to rest the ends of both legs on the pegs after their tops have been brought to a level. Then one man at one end will raise the leg he holds to certain heights measured on a rule he holds on the peg, while another man will mark the position the string occupies on the cross-bar and will mark it on the grade. Thus falls of 1/16, 1/8, 1/4, etc., of an inch per station will be obtained, the stations being equal to the spread of the triangle, or base of the A-frame. It is not claimed that the A-frame originated among the pioneer miners of California, but it was used by them to lay out some of the longest ditches and tunnels constructed in the early days of mining in that State.

A STUDY OF RIFFLES FOR HYDRAULICKING*

Riffles are artificial obstacles laid in a sluice for the purpose of lowering the speed of the materials carried in the sluice, classifying them while impeding their course as little as possible, and giving the precious metals or other valuable materials a chance to deposit at the riffle before reaching the end of the sluice. The heavier the metal or material to be saved, the easier is its recovery. The maximum recovery with the minimum loss will be reached when the interval, the shape, the depth, and the nature of the materials used for riffles is such that they are not liable to great changes due to wear, but will maintain their original saving-capacity. This consideration of maximum efficiency has been the object of this special study of riffles, involving their shapes and the different materials of which they may be most economically constructed.

Considerations Governing Choice of Materials

In a hydraulic mine, the choice of materials for riffles depends upon first cost, cost of transportation, cost of maintenance, facility of supply, etc. It is general practice to use the most convenient and handy material without consideration of its real economy. This course is far from wise, especially when low-grade gravels are being handled, necessitating that the riffles always operate at their maximum saving-capacity in order to accommodate the large amount of material which the low grade of the deposit requires shall be treated. Conditions in such a low-grade deposit require that the riffles shall: (1) Oppose a minimum resistance to the movement of the material; (2) resist wear; (3) maintain their saving capacity at its highest point; (4) be sufficient in number to recover all the gold commercially recoverable. The necessity of a minimum resistance to transportation is due to the fact that the water must be made to perform the highest possible duty. A high resistance to wear reduces the work of replacing and maintaining the riffles and also preserves their saving capacity.

It is an important question as to whether the riffles be placed longitudinally or across the sluiceway, both methods having their advantage, according to whether there is wanted a riffle with a short lifetime or one with a long lifetime.

Wooden Blocks Used

In my first experiments, I used riffles of wooden pine blocks 13x13x13 in., or 16x16x13 in., set in rows across the sluice, each row being separated from its neighbor by a crosspiece of 2x3 in. material 6 ft. long. The arrangement of the block is shown in Fig. 2. These blocks were pressed tightly

*Pierre Bouery in Eng. & Min. Journ.

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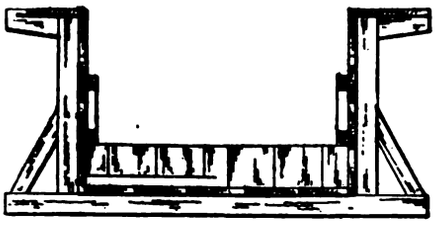
together and nailed to the cross-pieces. They were held down along the edges by 3x4-in. by 12 ft. strips, while higher on the sides of the sluiceway, and resting on the strips, were 3x12x12 in. pine blocks, to protect the sides from wear. Riffles such as these were used in the first 40 boxes of the sluice, each box being 12 ft. long; the lower boxes were paved with boulders, set on a false bottom, as seen in Fig. 3, their object being to overcome the impact of the tailings.

The life of the wooden blocks was from 45 days to three months, according to their place in the sluiceway, those in the higher boxes lasting longer than those below. The boulders lasted longer, but it was difficult to keep them in place. When it was necessary to replace worn material we had to clean up the bottom altogether so that the blocks might rest smoothly on the bottom board. This was not only an inconvenience but an extra expense. The difficulty became more acute when we attempted to increase the efficiency of our water. This was not easy to do; but by changing the system of piping we obtained an increase in efficiency of 40% or more. However, this increased duty decreased the life of the blocks about 60%, so that in every 17 days of a full run, we had to clean up. This annoyance and expense, together with the fact that our supply of pine blocks was limited by the life of the neighboring forest led me to experiment with other materials.



CROSS SECTION

FIG.4
LONGITUDINAL-SECTION

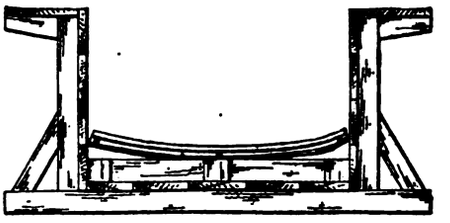


FIG.7

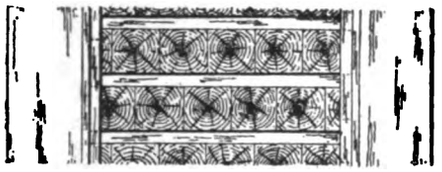
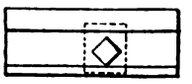


FIG.2-PLAN



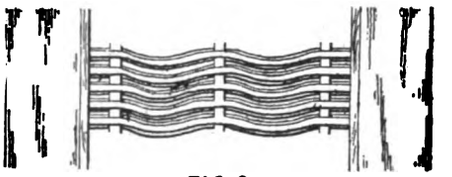
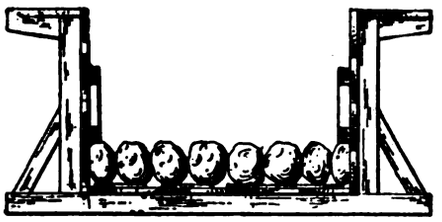


FIG.8



CROSS-SECTION

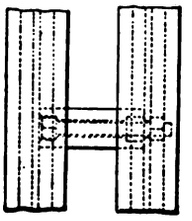


FIG.5
SPECIAL SPACING BLOCK

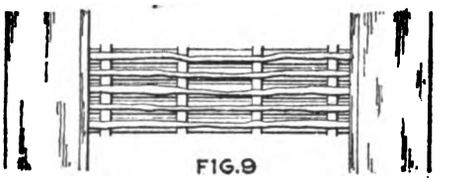


FIG.9

FIG.3 PLAN

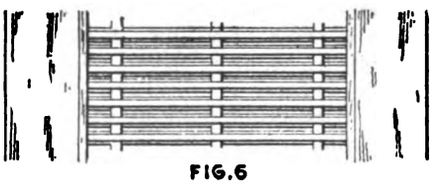


FIG.6

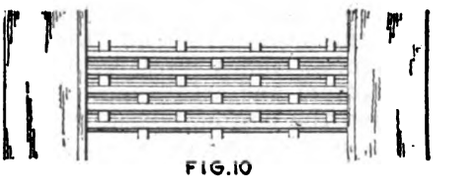


FIG.10

FIG.13-ELEVATION

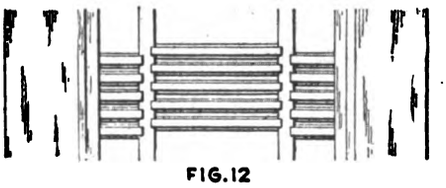


FIG.12

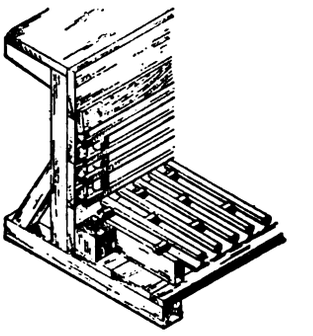


FIG.11

FIG.14

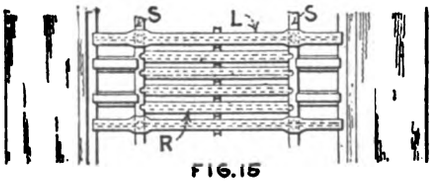
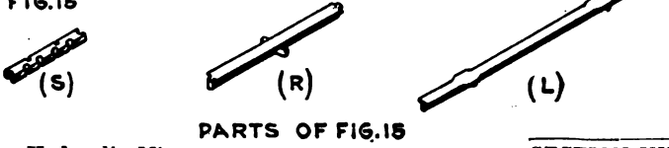


FIG.15



PARTS OF FIG.15

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Experiments Undertaken With Steel Rails

I began with steel rails, and used my previous experience obtained by setting these crosswise in the sluice. I had my choice of 16-, 25-, 45-, and 55-lb. rails, but decided that the 16- and 25-lb. were too light, while in the 55-lb., the web and flange were too large in comparison with the head. Consequently I decided on the 45-lb., which I have since changed to a 40-lb. rail as being more economical.

The determination of the proper spacing was important and was deduced from a series of experiments which considered the grade of the sluice and the thickness of the layer of running water on the riffle. The relation between the velocity of the water and the material carried can be expressed in the form of a curve, but I omit formulas in this discussion. I conducted some experiments in clear water by throwing in special small rocks, then turning off the stream, finding the rocks and measuring the distance they had traveled. This was not an extremely valuable experiment, but it gave suggestions. A particle of material carried along by the water may fall between two riffles or it may strike one riffle and bound off. In either case the final result will be for the particle to come to rest between two riffles and remain there until dislodged by a stronger force. The grade in the sluices was seven or eight inches to the box of 12 ft. and the depth of water varied from 12 to 18 in. A spacing of five inches between the center of the rails was decided upon as the best interval. For other grades and other depths different spacing intervals would probably be more advantageous, but I question whether it would pay to go below four inches or above six, as the first case would increase the expense and the second might create obstacles between the rails, which would interfere with dumping the tailings.

Wooden Riffles Under the Rails

Further investigation convinced me that the height of the rails alone could not give sufficient depth for saving the gold and, furthermore, that with the base of the rail directly on the bottom of the sluice, eddies were formed which might wear the bottom and create new troubles. Therefore, I covered the bottom boards with a series of wooden riffles as seen in Fig. 4, made of 2x6-in. pieces six feet long, with blocks nailed to them to provide spaces for gathering the gold, and on these the rail riffles were set, thus acting really only as a protection to the wooden riffles below. I fitted out two boxes in this fashion and set them in place of boxes 20 and 21, in order to have them removed from the blockades at the head of the sluice. Boxes 1 to 19 inclusive had the original wood riffles and boxes 22 to the end were paved with boulders.

At the end of three months, when the blocks were worn out, boxes 19, 20 and 21 were cleaned separately and their contents kept apart. In ordinary circumstances, box 19 would have contained more gold than box 20, but, as a matter of fact, there was in box 20, 2½ times as much gold as in box 19, and in box 21, a little less than twice as much as in box 19. These conclusive results induced the directors to allow me to install new riffles instead of the old type.

While the results obtained with the rails were better than with the pine blocks and boulders, they were not altogether satisfactory. For one thing, there was a great increase in the duty of the water and a consequent greater increase in the wear on the riffles. But the result of the year's run on the new system showed that the gravel never packed hard between the rails and also that gold, whether free or amalgamated, was never found between the rails.

Cast-Iron Spacers in Different Combinations

In the use of rails, it is necessary that they be kept independent and at the same time solid. To obtain this result, a special filling-block shown in Fig. 5 was designed and made of cast-iron. The shape of this block, conforming to the shape of the rails, made a solid system in the sluiceway, and prevented the rails from upsetting. This last is an important point, as, if for any reason the surface of the riffles becomes unequal in the sluiceway, obstacles are created and the discharge of material is impeded. The original disposition of the spacing blocks is shown in Fig. 6, three blocks being used for each 6-ft. length of rail. The wear is much greater in the center of a sluiceway than on the side, and as a result, after a few months' run, the rails placed in this way become curved in one direction or the other, as seen in Figs. 7 and 8. To correct this, four blocks were used as shown in Fig. 9, with the result that bending was eliminated, but in the center of the sluiceway, in the channel formed by the two middle blocks, the attrition was severe, so that the rails wore and broke at this place while still good on the end. The final arrangement is that shown in Fig. 10, using seven spacing blocks for each pair of rails. In this manner it was found that when discarded, the rails were ⅝ worn out instead of ⅜ as formerly. During these experiments, the shapes of the blocks were also changed to arrive at the point of highest economy.

Sides of Sluice Protected With Scrap Rail

The ends of the worn rails were utilized to protect the sides of the sluice box from wear. Their arrangement for this purpose is that shown in Fig. 11. The rail ends were bolted together in sets of four by long bolts at the ends, with special spacing blocks to keep the heads apart. They were held against the side of the box by nails bent over the flange of the top rail and by a 2x6-in. board, also set on the top flange. This arrangement did not so much increase the duty of the water as it decreased the expense due to replacing the wooden blocks formerly used for this purpose. These side rails usually lasted from five to seven years and handled about 30,000,000 cu. yd. of gravel.

High-Class Material Is Usually Cheaper

The cost of riffle material can be considered as made up of first cost at the manufacturing plant and transportation cost. Where transportation is high, it pays to use a high-class material. There is, however, a limit, at which a low cost-price plus the high cost of repeated transportations is equal to a high cost-price plus the low cost of a single transportation. How high a price for material is it worth while to pay in such circumstances? Consider two sluices working under similar conditions, that is, for the same length of time, with the same quantity of water and handling the same amount of material. Suppose that in the first sluice the riffle material is renewed every year, while in the second sluice the material will last N years. Let the cost

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at the manufacturing plant of the riffle material for the first sluice be A, and the transportation cost be B. In N years' run the cost of riffles for the first sluice will be $N \times A + N \times B$. Let X equal the cost at the manufacturing plant of the material for the second sluice; then in N years' run the cost of the sacond sluice is $X + B$. Supposing these costs to be equal, then $N \times A + N \times B = X + B$; or $X = N \times A + (N - 1)\ B$. When X is equal to the second term, there is no economy in buying material at that price, but if X is smaller, the economy increases approximately as N, the number of years, increases.

In addition to the direct saving due to using high-class material, there is the saving in labor and interruption to operations, due to replacing worn riffles. The cost of these operations decreases as the frequency of replacements decreases. In order to find out what material was really the most economical, we considered experiments with titanium steel, chrome steel, cast steel, nickel steel and manganese steel. Nickel and chrome steels we could not obtain, but we experimented with the other steels and, as a result, selected manganese steel as being preferable to the others.

Attempts to Utilize Scrap Rail

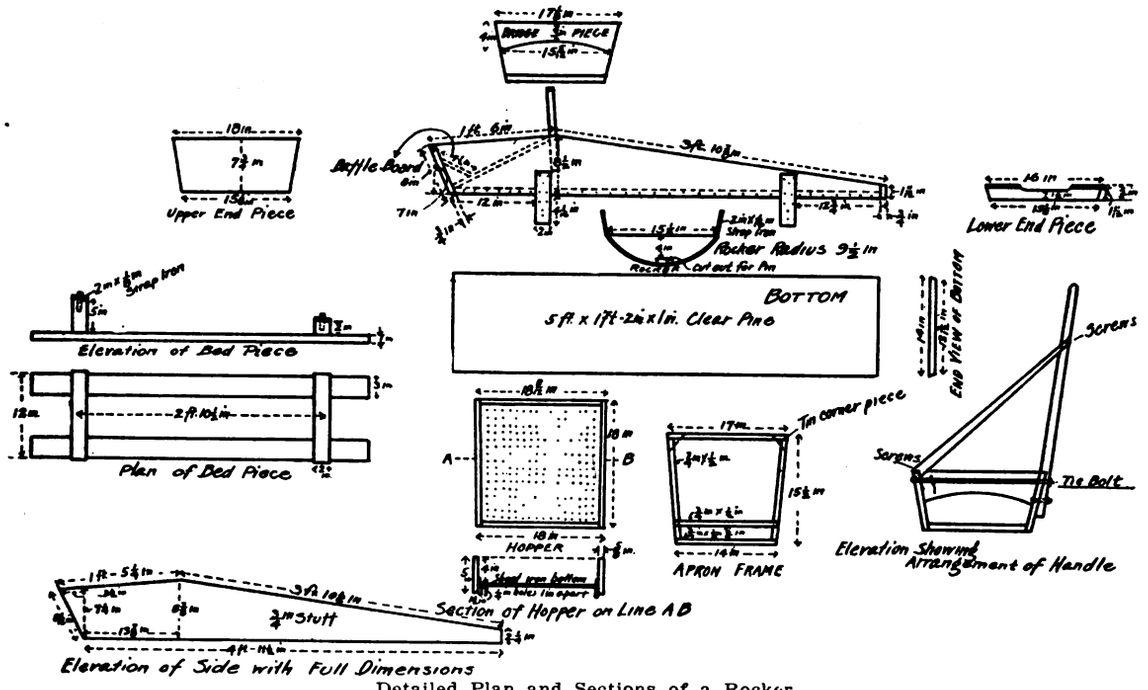
In spite of using the ends of the rails for lining the sluice sides, we found that the scrap pile was growing far too large. Consequently we tried setting the scrap rails with the flanges uppermost in the sluice. The rails, however, had become brittle; apparently a molecular change had taken place and crystallization resulted, so that they were quite unavailable. Lacking means to anneal them, we built a primitive furnace, heated them to a cherry red and found we obtained a rail satisfactory, so far as brittleness was concerned, but subject to rapid wear on account of having lost its temper. The idea occurred to our foreman of bolting five rails together and putting them flange up in the sluiceway, but between each flange, putting two pieces of broken rail projecting above the flanges. This gave a satisfactory result and aided materially in reducing the scrap pile.

Method of Using Short Rail Sections

Figs. 12, 13, 14 and 15 illustrate other expedients used to use short sections. In these arrangements high-class riffles are used in the middle sections. These methods proved satisfactory and Fig. 15, shows type now in use. Details of parts are shown in (S), (R) and (L).

ROCKER FOR WASHING GRAVEL

The following details represent a rocker which in the hands of a fairly careful man will give very clean results. It is a rocker that handles well and can be easily run. The only new feature about it is the baffle-break used at the upper end which throws any drippings from the upper holes in the hopper on the apron. A piece of brussels carpet 13½ in. is laid on the floor of the rocker to catch the fine specks of gold. This carpet, which extends for a distance of three feet from the upper end, is held in place by the crosspiece at the foot of the apron frame and by two strips, one on either side of the rocker. These strips are held down by wedges driven under small cleats nailed to the sides of the rocker. Very thin canvas or flour sacking should be used for the apron so that it can bag slightly.



Detailed Plan and Sections of a Rocker

*W. H. Radford in Min. & Sci. Press.

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Separating Platinum From Sand *

A great deal of mystery has surrounded the problem of recovering gold and platinum from so-called "black sand." Many believe that the precious metals therein contained are not in a form which can be determined by ordinary methods and that vast riches await the man with the proper process for their recovery. The gold and platinum really occur in fine thin scales, which can be assayed readily, but which, by their nature, are somewhat difficult to concentrate. The process generally used is some form of sluice box, shaking or bumping table, classifier, or special device invented for the purpose. Chemical means have also been used, but such methods are in the minority and are generally practiced in conjunction with gravity concentration.

As platinum does not readily amalgamate, the use of mercury is usually ineffectual in any separation process. The general procedure is to save all the heavy black-sand concentrate accumulating from placer mining or dredging operations and at stated intervals treat it for its platinum content. It has been the practice for some hydraulic miners to discard the black sand as valueless, but owing to the high prices of platinum prevailing during the last few years, attention has been directed from time to time to a recovery of the precious metal. Although the black sand usually contains most of the platinum, part of the metal may be recovered in the main operations with the amalgam.

The familiar Western "Long Tom," a trough-shaped gold-washing device, may be used to handle the black sand, the platinum being recovered by panning the long-tom concentrate several times. Logan, in "Platinum and Allied Metals in California," from which the following details of practice have been taken, describes the procedure at Oroville, where the Natomas Consolidated black-sand concentrate and amalgam is collected in a box and run through a long tom until it is reduced to one-half a small bucketful. The long tom used is 1 ft. wide and 12 ft. long, and rests on the gold tables so that it has a grade of one inch to a foot. The upper 4 ft. of the long tom is covered with small iron riffles in solid sections 1 ft. long, the cross riffles being an inch apart, sloping back. The bottom is lined with coco matting under expanded metal.

From the long tom the concentrate is taken to the clean-up room. The bulk of the amalgam is separated easily and retorted. The black sand, containing platinum, a small amount of amalgam and rusty gold, is washed several times in a miniature long tom and the bulk reduced to about one pint, which contains the gold and platinum-group metal. The surplus quicksilver is drawn off and the concentrate subjected to a boiling motion imparted by pouring it back and forth between two ordinary crockery bowls to remove nearly all the black sand. Concentrated nitric acid is applied to remove any base metal and to brighten the rusty gold so that it will amalgamate. The platinum can finally be cleaned by magnet and blower.

The platinum in the Oroville district is uniformly fine as flakes or grains. Logan states that the best results are probably not obtained where panning and the long toms are used. Dredging superintendents generally are satisfied with any results which approximate the usual yield of platinum, reasoning that the platinum is in such small quantity at best that more careful work is not justified.

Yuba Consolidated Goldfields employs a different method of recovery. Each dredge supplies about three tons of concentrate per week, and a total of sixty to seventy tons of this product is treated monthly. The sand handled is the black sand from the long toms, one of which is used on each dredge to recover as much gold and platinum as can be got in a rich concentrate of small bulk. The sand is ground in batches for two hours in a steel ball mill with a weak cyanide solution to brighten the rusty gold. The slime is then discharged into a well, from which it is pumped into a small settling tank and subjected to cyanide treatment in a miniature plant housed in the same building. Leading from the ball mill is a string of sluices 40 ft. long and 1 ft. wide, with a grade of one inch to the foot, which contain a mercury trap, 2 ft. of silverized amalgamating plate, 3 ft. of iron cross riffles such as are used in long toms, 5 ft. of coco matting, and 8 ft. of wooden riffles loaded with mercury, the remainder of the sluice being covered with coco matting under expanded metal. After the slime has been drawn off, the mill is allowed to run open and the sand discharges into the sluice. About $40 per ton in gold and platinum is recovered. The gold extraction is nearly perfect.

The Marysville Dredging Co., after recovering the hard amalgam in a long tom, sacks the black sand and transfers it to a clean-up room, where it is run through a long tom 12 ft. long fitted with iron riffles. The sand is then rocked in a common rocker. A 3-ft. arrastra is next used to grind the sand in small portions. A little sulphuric acid is used to brighten the rusty gold, most of which is caught in the arrastra. The sand is finally washed through a Colorado amalgamator and the rocker and arrastra concentrate panned several times.

In the Natoma district, according to Logan, "It is stated that the Neill jigs do not save any platinum, although successful in gold saving." Senn pan-motion bateas are used for the final recovery. Small Hardinge mills grind the sand, and the sand passes from the mills onto an amalgamated plate 2 ft. wide and 10 ft. long and thence to the Senn machine operated at 160 r.p.m. The concentrate yielded is 10 to 30 per cent black sand, the gold is practically all amalgamated on the batea, and the platinum caught in the bowl at the center. In finally separating the platinum the batea concentrate is screened, as it has been found to be much easier to get the platinum from sand of its own screen size than from sand of all sizes. Some sand stops on a 40-mesh screen; some of the platinum and sand grains are fine enough to pass 100 mesh. The material entering the Hardinge mill carries about $75 per ton in metals, and the tailing from the batea assays about $1 gold and $1 platinum.

Other methods also are practiced. A submerged table as the chief concentrating unit in the Huelsdonk Submerged Table Concentrator is used successfully at the La Grange mine. It is a compact unit that can be adapted to small operations.

We do not know of any operation employing dry concentration, oil flotation, or the Wilfley table as such.

*Engineering and Mining Journal, February 11, 1922.

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HYDRAULIC MINING AND DREDGING DATA

DUTY OF MINER'S INCH, ALASKAN DISTRICT

Location	Height of Bank, Feet	Character of Material	Grade in. Per 12 Ft.	Miner's in. of Water	Duty Cu. Yd. Per Miner's in.	Sluices		Riffles
						Width, in.	Depth, in.	
Juneau:								
Windfall Cr.	16	.....	.....	1000	2.0	..	..	.....
Gold Creek	200	Heavy stones	4.5	4000	2.0	72	60	Block
Silver Box Basin	80	Heavy stones	4	2500	2.0	50	55	Block
Atlin:								
McKee Cr.	40	Heavy stones	8	700	1.5	32	32	Angle iron & block
McKee Cr.	85	Heavy stones	8	1200	3.0	32	40	Angle iron & block
Birch Cr.	25	Heavy stones	5.25	1200	0.5	30	30	Block
Spruce Cr.	29	Heavy stones	5	1200	1.0	40	36	Block
Spruce Cr.	20	Heavy stones	5.5	900	0.5	48	32	Block
Pine Cr.	20	Heavy stones	3	700	0.6	36	36	Rail
Pine Cr.	60	Heavy stones	5	3500	0.625	60	40	Block
Dawson:								
Bonanza Cr.	20	Small round gravel, frozen	12	250	5.0	24	20	Block
Bonanza Cr.	25	Small gravel, frozen	12	125	4.0	20	16	Sawed pole
Bonanza Cr.	25	Small round gravel, frozen	11	150	10.0	24	24	Block
Bonanza Cr.	35	Small round gravel, frozen	12	200	6.5	24	24	Block
Bonanza Cr.	75	Small round gravel, frozen	12	266	8.0	24	30	Block
Eldorado Cr.	60	Small round gravel, frozen	11	160	7.0	24	24	Block & Hungarian
Last Chance	46	Small round gravel, frozen	12	230	7.0	24	18	Pole & Block
Last Chance	25	Small round gravel, frozen	14	120	5.0	20	20	Pole, ironshod
Hunker Cr.	15	Small round gravel, frozen	13	150	2.0	14	14	Pole & Block
Hunker Cr.	8	Small round gravel, frozen	12	125	2.6	17	14	Pole, iron-shod
Nome:								
Anvil Cr.	30	Heavy, partly frozen	4.5	500	1.4	33	18	Angle iron
Anvil Cr.	20	Frozen earth	4.5	400	10.0	..	..	Angle iron
Anvil Cr.	12	.....	9	100	.....	16	14	Angle iron
Glacier Cr.	20	Flat, semi-frozen gravel	6	760	1.32	36	24	Angle-iron grates
Dexter Cr.	40	Heavy gravel	6.5	100	2.0	16	16	Angle-iron grates
Newton Cr.	8	Coastal plane gravel	7	150	3.33	24	24	Pole & angle iron
Basin Cr.	20	Heavy gravel	8	250	0.6	18	18	Pole, iron-shod
Council:								
Ophir Cr.	12	Heavy gravel	10	200	1.5	24	16	Rail & Angle
Ophir Cr.	8	Slabs and Clay	10	750	1.0	24	16	Rail & Angle
Solomon River	5	Subangular gravel	10	600	0.8	37	24	Angle grates

U. S. G. S. Bulletin No. 262.

GENERAL STATISTICS CONCERNING DREDGES USED IN MONTANA

Item.	Steam dredges.			Electric dredges.			
	Maggie Gibson.	Conrey No. 1.	Conrey No. 2.	Conrey No. 1.	Conrey No. 2.	Conrey No. 3.	Conrey No. 4.
Power used	Steam	Steam	Steam	Electricity	Electricity	Electricity	Electricity.
Date built	1896	1899	1901	1908	1908	1906	1911.
Type	Double-lift sluice	Single-lift sluice	Single-lift sluice	Single-lift table stacker.	Single-lift table stacker.	Single-lift table stacker.	Single - lift table stacker.
Anchorage	(a)	Lines	Lines	Spud	Spud	Lines	Spud.
Average monthly yardage worked, cubic yards.	27,000	41,360	52,520	96,270	62,709	82,415	300,000.
Hull dimensions:							
Draft	5 feet 3 inches	5 feet 4 inches	5 feet 9 inches	5 feet	5 feet 6 inches	6 feet	9 feet.
Length	110 feet	100 feet	110 feet	96 feet	102 feet	130 feet	150 feet.
Width	35 feet	44 feet	44 feet	44 feet	44 feet	48 feet	58 feet.
Depth	7 feet 6 inches	7 feet 6 inches	7 feet 6 inches	9 feet	9 feet	7 feet 11 inches	13 feet.
Pontoon dimensions:							
Length	30 feet	38 feet 6 inches	40 feet	None	None	50 feet	None.
Width	24 feet	35 feet	29 feet			40 feet	
Depth	4 feet	3 feet	3 feet 10 inches			3 feet 11 inches	
Stacker dimensions:							
Length	None	None	None	90 feet	85 feet	None	130 feet.
Width of belt				34 inches	34 inches		4 feet.
Motor drive				Upper end 30 feet	Upper end 30 feet		Upper end 55 f...
Tailing height							
Dimensions of steel spuds:							
Length, feet	None	None	None	48	54	None	80.
Width, feet				3	3		4½.
Thickness, feet				2	2		3.
Weight, pounds				26,500	29,000		88,000.
Number				1	1		2.
Dimensions of wooden spuds:							
Length, feet	None	None	None	48	54	None	None.
Width, feet				3	3		
Thickness, feet				2	2		
Number				1	1		
Horsepower:							
Bucket chain	45	60	73	100	100	150	550.
Trommel	5	6	8	30	30	10	100.
Pumps	40	79	147	160	160	175	285.
Winches	10	12	4	20	20	115	250.
Miscellaneous	None	19	16	70	70	10	50.
Total horsepower	100	176	248	380	380	460	1,235.

(a) Originally spud; changed to lines.

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GENERAL STATISTICS CONCERNING DREDGES USED IN MONTANA—Continued

Item.	Steam dredges.			Electric dredges.			
	Maggie Gibson.	Conrey No. 1.	Conrey No. 2.	Conrey No. 1.	Conrey No. 2.	Conrey No. 3.	Conrey No. 4.
Ladder data:							
Length, feet	70	82	95	69	80	100½ *a*	116.
Type	Queen truss	Queen truss	Lattice girder	Lattice girder	Lattice girder	Lattice girder	Plate girder.
Depth of digging below water, feet.	29	35	40	30	35	45	55.
Dimensions of tumblers:							
Upper tumbler—							
Distance above deck	12 feet 7 inches	24 feet 6 inches	29 feet 3 inches	25 feet 9 inches	29 feet 3 inches	31 feet	35 feet 6 inches.
Weight, pounds	2,000	2,000	4,050	8,970	8,970	8,970	16,000 to 25,300.
Number of sides	5	5	5	6	6	6	6.
Shaft diameter, inches	9	11	12	16	16	16	25.
Lower tumbler—							
Weight, pounds	3,000	2,500 to 3,075	4,600	5,800	5,800	5,800	18,000 to 19,800.
Number of sides	6	6	6	6 to round	6 to round	6 to round	6 to round.
Shaft diameter, inches	6	6 to 8½	10	13¼	13¼	13¼	15⅝.
Bucket-chain data:							
Type	Open link	Open link	Open link	Close connected	Close connected	Open link, later changed to close connected.	Close connected.
Drive	Sprocket	Sprocket	Sprocket	Belt	Belt	Gear	Gear.
Weight, pounds	40,000	104,000	125,000	169,000	225,000	297,000	357,500 to 415,300.
Capacity of buckets, cubic feet	5	5 to 7½	10	7½	7½	13 open, 9½ closed	16 to 17.
Number in chain	35	41	41	60	80	43 open, 80 closed	80.
Weight, pounds	750	750 to 1,500	1,850	2,594	2,594	2,900	4,468 to 5,191.
Pitch, inches	26	26 to 29⅜	31 5/16	32¾	32¾	32¾	40.
Buckets dumped per minute	7	5 to 11	5 to 11	16	15	15	18 to 22.
Type	2-web	2-web	3-web	3-web	2-web	2-web	2-web.
Material	Steel	Steel	Steel	(*b*)	(*b*)	(*b*)	(*b*).
Hood and base, number of pieces	2	2	2	2	(*c*)	(*c*)	1.
Links—							
Weight, pounds	300	770	900			1,250	
Pitch, inches	26	29⅜	31 5/16			32¾	
Number in chain	35	40	40	None	None	43	None.
Material	Steel	Steel	Steel			Steel	
Type	2-web	2-web	3-web			3-web	
Pins—							
Diameter, inches	3	3 to 4⅝	4⅞	4⅝	5	5	7 to 8.
Weight, pounds	50	50 to 130	155	168	184	184	520 to 495.
Material	Steel	Steel	Steel	Steel	(*b*)	(*b*)	(*b*).
Type	Double lug	Lock pin	Lock pin	Single lug	Single lug	(*d*)	Single lug.
Pin bushings—							
Type	Half circle	Full circle	Full circle	Full circle	Full circle	Full circle	Full circle.
Material	Manganese	Manganese	Manganese	Manganese	Manganese	Manganese	Manganese.
Trommel data:							
Length	14 feet	16 feet	15 feet 2 inches	35 feet	35 feet	18 feet	48 feet 6 inches.
Diameter, inches	48	46	48	51 to 72	51 to 72	61	98.
Type	Straight cylinder	Straight cylinder	Straight cylinder	Stepped cylinder	Stepped cylinder	Straight cylinder	Straight cylinder.
Drive	Sprocket	Sprocket	Sprocket and bevel gear.	Belt	Belt	Belt	(*e*).
Plates—							
Thickness, inches	⅝	⅝	⅝	⅝	⅝	⅝	1.
Material	Steel	Steel	Steel	(*b*)	(*b*)	(*b*)	(*b*).
Perforations	4 by 4 inches	4 by 4 inches	4 by 4 inches	½ to ¾ inch	½ to ¾ inch	4¼ by 6 inches	½ to ¾ inch.
Dimensions of tables:							
Grade, per cent				12½	12½	12	12½
Number				20	20	10	24
Width, inches	None	None	None	30	30	30	30.
Length, feet				18	18	12	11 to 29¾.
Riffles (angles), inches				1¼	1¼	1¼	1¼.
Perforated plates						⅜-inch hole	
Pump data:							
Number	2	2	3	4	4	5	3.
Size and kind	4-inch water 12-inch gravel	10-inch water 14-inch water	10-inch water Two 14-inch water.	3-inch water 8-inch water 12-inch water 6-inch sand	3-inch water 8-inch water 12-inch water 6-inch sand	3-inch water Two 10-inch water. 12-inch water 14-inch water	4-inch water. 14-inch water. 16-inch water.
Make	Morris	Morris	McKay	Morris	Morris	Morris-Worthington.	Worthington.
Gallons per minute	4,000	6,500	8,100	6,700	6,700	12,500	12,000.
Main winch data:							
Length	12 feet	26 feet	26 feet	20 feet 1 inch	20 feet 1 inch	11 feet 10 inches	29 feet 10 inches.
Width	6 feet	16 feet	16 feet	4 feet 11 inches	4 feet 11 inches	8 feet 6 inches	7 feet 5 inches.
Diameter of drums, inches	16	16	16	16	16	30	24.
Number of drums	6	8	8	8	8	2	8.
Tail sluices:							
Grade, per cent				12½	12½		12½.
Number				2	2		12.
Length, feet	None	None	None	40	40	None	17 to 44.
Width, inches				48	48		48.
Riffles (angles), inches				1¼	1¼		1¼.
Undercurrents:							
Grade, per cent		10	10			10	12½.
Number		1	1			2	12.
Length, feet		40	60			54	7½.
Width, inches	None	10	10	None	None	13	34.
Riffles—							
Material		Wood	Wood			Wood	Angles.
Size, inches		1 by 1½	1 by 1½			1 by 1½	1¼.
Perforated plates:							
Width of slots, inches		1/16	1/16			1/16	¼.*f*
Well save-all:							
Grade, per cent		8	8	8	8	8	8.
Number	None	1	1	1	1	1	1.
Length, feet		30	30	7½	7½	25⅛	18½.
Width, inches		12	12	18	18	18	18.
Upper flume:							
Grade, per cent		5	5			6	
Riffles—							
Material	None	Wood	Wood	None	None	Angles	None.
Size, inches		1½ by 2	1½ by 2			2 by 2½	
Length		21 feet	22 feet			28 feet 10 inches	
Width, inches		42	50			62	
Lower flume:							
Grade, per cent	5	5	5			6	
Riffles—							
Material	Wood	Wood	Wood	None	None	Angles	None.
Size, inches	2 by 4	2 by 4	2 by 4			2 by 2½	
Length, feet	103	120	120			135	
Width, inches	38	52	52			66	
Total gold-saving area, square feet	320	656	692	1,231	1,231	1,264	3,000.

c Steel buckets in two pieces; manganese in one.

e Gear; later changed to belt.

f Holes instead of slots.

U. S. Bureau of Mines, Bulletin No. 121.

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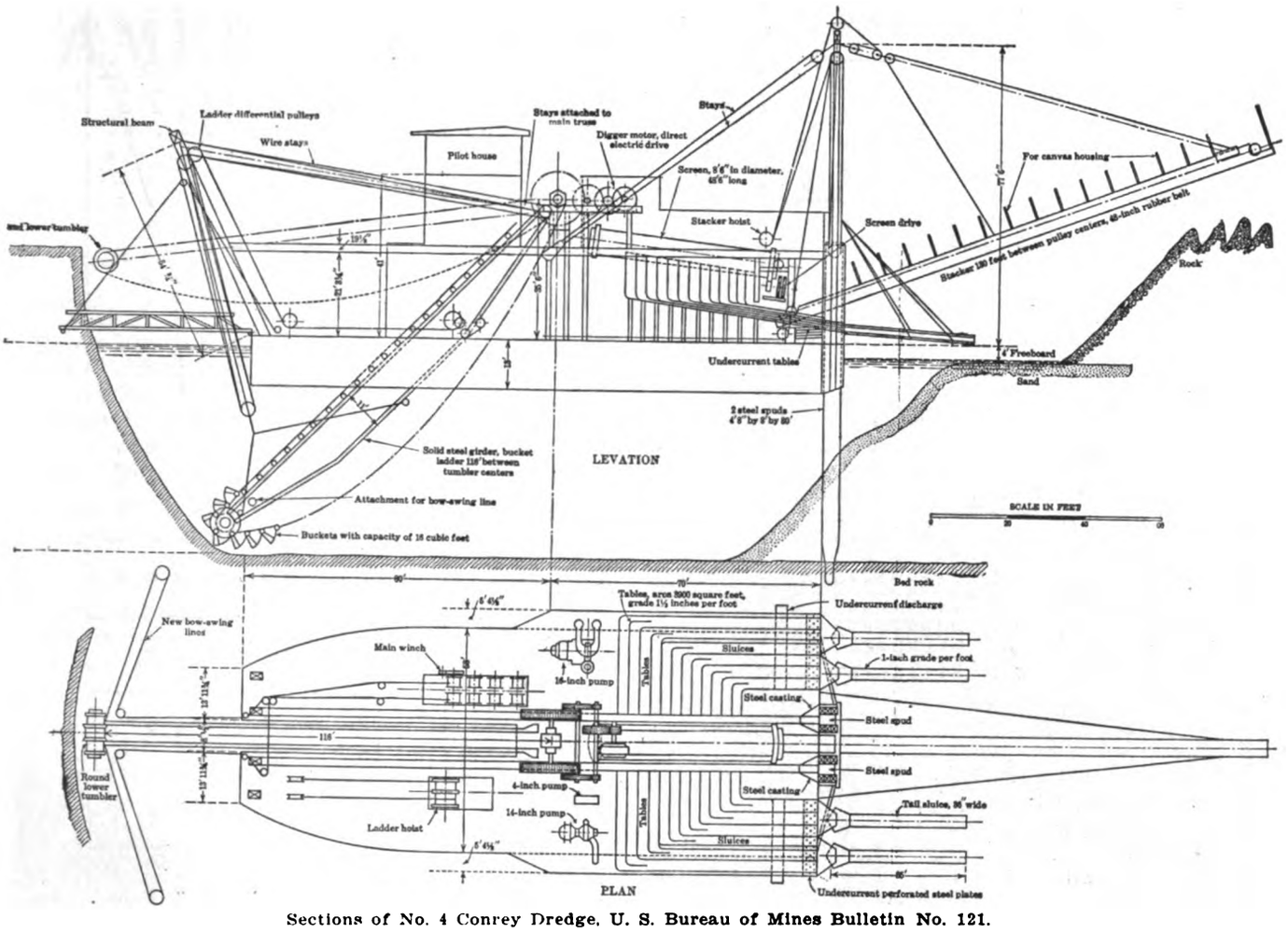

Sections of No. 4 Conrey Dredge, U. S. Bureau of Mines Bulletin No. 121.

GOLD TABLE

For Determining the Value of Free Gold Per Ton (2000 lbs.) of Quartz or Cubic Yard of Gravel

Weight Washed Gold	Fineness, 780	Fineness, 830	Fineness, 875	Fineness, 920
4-Lb. Sample Grains	Value Per Oz. $16.12	Value Per Oz. $17.15	Value Per Oz. $18.08	Value Per Oz. $19.01
5 grains	$83.97	$89.36	$94.20	$99.05
4 grains	67.18	71.49	75.36	79.24
3 grains	50.38	53.61	56.52	59.43
2 grains	33.59	35.74	37.68	39.62
1 grain	16.79	17.87	18.84	19.81
.9 grains	15.11	16.08	16.95	17.82
.8 grains	13.43	14.29	15.07	15.84
.7 grains	11.75	12.51	13.19	13.86
.6 grains	10.07	10.73	11.30	11.88
.5 grains	8.40	8.93	9.42	9.90
.4 grains	6.71	7.14	5.53	7.92
.3 grains	5.03	5.36	5.65	5.94
.2 grains	3.36	3.57	3.76	3.96
.1 grain	1.68	1.78	1.88	1.98

EXPLANATION OF GOLD TABLE

The table furnishes an exceedingly simple method of determining the value of **free** gold in a ton of gold-bearing quartz, or a cubic yard of auriferous gravel.

Take a sample of four (4) pounds of quartz, pulverize it to the usual fineness for horning; wash it carefully by batea, pan, or other means; amalgamate the gold by the application of quicksilver; volatilize the quicksilver by blowpipe or otherwise; weigh the resulting button, and the value given in the table opposite such weight will be the value in free gold per ton of 2000 pounds of quartz.

Example.—Sample of four pounds produces button weighing one grain, the fineness of the gold being 830; then the value of one ton of such quartz will be $17.87.

If the sample of four pounds should produce a button weighing, say four-tenths of a grain (.4), then the value of such quartz would be (830 fine) $7.14 per ton.

GOLD VALUE OF A CUBIC YARD OF GRAVEL

To determine the gold value of a cubic yard of auriferous gravel, the same table can be used.

Take a sample of sixty (60) pounds of gravel, pulverize it, and carefully wash it by batea, pan, or otherwise; amalgamate the gold, volatilize the quicksilver; weigh the button, and in column in table, opposite the weight, will be found the gold value of the cubic yard of gravel.

Example.—Sample of sixty pounds produces button weighing one grain, the fineness of the gold being 780; then the value of one cubic yard of such gravel would be $1.68. This is arrived at by pointing off one point, or dividing the value given in table by 10.

If the sample of sixty pounds yields a button weighing five-tenths (.5) of a grain, then the value of the gravel would be—gold being 780 fine—$0.84 per cubic yard.

WATER MEASUREMENT—THE MINER'S INCH

In California the miner's inch is the flow of about 8.796 gallons of water per minute. Fifty miner's inches are equivalent to one cubic foot per second. The most common measurement is under a mean pressure of four inches, through an aperture 2 inches high and 2 inches above the bottom of the box, the plank being 1¼ inches thick, and the height of water above the aperture 3 inches, giving a mean pressure of 4 inches. Each square inch of the aperture represents one miner's inch, or about 1.2 cubic feet flow per minute.

CARRYING POWER OF WATER

Veloc., Ft. per Min.	
15	Begins to wear away fine clay.
30	Just lifts fine sand.
40	Carries sand as coarse as linseed.
60	Moves fine gravel.
120	Moves pebbles 1 in. diam.
180	Moves pebbles of egg size.

Min. & Sci. Press.

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ELECTRICAL EQUIPMENT AND POWER CONSUMPTION ON CALIFORNIA DREDGES

Dredge	Main Drive Motors. H.P.	Make.	V. or C.[1]	Volts.	R.P.M.	Type.	Screen Motors. H.P.	Make.	V. or C.	Volts.	R.P.M.	Type.	Stacker Motors. H.P.	Make.	V. or C.	Volts.	R.P.M.	Type.	Side-Line Winch Motors. H.P.	Make.	V. or C.	Volts.	R.P.M.	Type.
Natoma No. 1......	300	G.E.	v.	550	514	....	75	G.E.	c.	550	720	..	35	G.E.	c.	550	600	..	35	G.E.	v.	550	514	..
Natoma No. 2......	200	G.E.	v.	2000	600	....	50	G.E.	c.	440	850	..	35	G.E.	c.	440	600	..	25	G.E.	v.	440	600	..
Natoma No. 3......	200	G.E.	v.	2000	600	....	50	G.E.	c.	440	850	..	25	G.E.	c.	440	600	..	25	G.E.	v.	440	600	..
Folsom No. 3......	150	West.	v.	2000	345	F	30	West.	c.	400	850	C	40	West.	c.	400	850	C	30	West.	v.	400	850	F
Folsom No. 4......	200	West.	v.	2000	580	H F	30	West.	c.	400	850	C	40	West.	v.	400	850	F	30	West.	v.	400	850	F
Folsom No. 5......	200	West.	v.	2000	580	H F	30	West.	c.	400	850	C	30	West.	c.	400	850	C	30	West.	v.	400	850	F
Folsom No. 6......	200	West.	v.	2000	600	H F	30	West.	c.	400	850	F	50	West.	v.	400	850	C	30	West.	v.	400	850	F
Yuba Nos. 9-10-11-12..............	200	......	..	....	....	....	35	......	..	....	....	..	25	......	..	....	....	..	25	......	..	....	....	..

Dredge	Motors on Pumps. Screen Supply. H.P.	Make.	V. or C.	Volts.	R.P.M.	Type.	Auxiliary Supply. H.P.	Make.	V. or C.	Volts.	R.P.M.	Type.
Natoma No. 1......	150[3]	G.E.	c.	550	600	..	35[3] 10[3]	G.E. G.E.	c. c.	440 440	600 1200	..
Natoma No. 2......	[3]	......	..	....	....	..	....	......	..	....	....	..
Natoma No. 3......	75[3]	G.E.	c.	440	720	..	35[3] 10[3]	G.E. G.E.	c. c.	440 440	600 1200	..
Folsom No. 3......	100	West.	c.	2000	580	C	50 30	West. G.E.	c. c.	2000 440	850 850	C I
Folsom No. 4......	100	West.	c.	2000	580	C	15	West.	c.	400	1120	O
Folsom No. 5......	100	West.	c.	2000	580	O	30 20	G.E. West.	c. c.	440 400	900 1100	I O
Folsom No. 6......	100	West.	c.	2000	850	O	50 30	West. West.	c. c.	2000 400	500 850	O O
Yuba Nos. 9-10-11-12..............	75	......	..	....	....	..	50	......	..	....	....	..

Dredge	Monitor. H.P.	Make.	V. or C.	Volts.	R.P.M.	Type.	Transformers.[5] Number.	Kw.	Volts.	Horsepower Totals. Capacity.	Output.
Natoma No. 1......	....	......	..	....	....	......	3 1[4]	175 5	4000–575	645	445
Natoma No. 2......	....	......	..	....	....	......	3 1[4]	125 5	4000–460	430	322
Natoma No. 3......	....	......	..	....	....	......	3 1[4]	125 5	4000–460	420	370
Folsom No. 3......	150[2]	West.	c.	....	850	O C L	3	37.5	2300–460	580	401
Folsom No. 4......	....	......	..	....	....	......	3	37.5	2300–460	415	260
Folsom No. 5......	50[3]	West.	c.	....	850	O C L	...?...	37.5	2300–460	490	484
Folsom No. 6......	150[3]	West.	v.	2000	580	F	......	37.5	2300–400	640	572
Yuba Nos. 9-10-11-12..............	....	......	..	....	....	......	......	......	4000–440	420	....

[1]Variable or constant speed. [2]Two motors. [3]Direct connected. [4]Light circuit. [5]Natoma division carries 4400 volts on boats and transforms to 440 volts; Folsom carries 2000 volts on boats and transforms to 440 volts for small motors.

DATA ON CALIFORNIA DREDGE EQUIPMENT

Dredge.	Hull Dimensions. Depth.	Width.	Length.	Digging. Length Ladders C. of Drums.	Dig below Water Line.	Carry Bank.	Water Supply. Miners' Inches.	Gold Tables. Combined Area, Sq. Ft.	Buckets. Capacity, Cu. Ft.	Number in Chain.	Travel. Feet per Minute.	Travel. No. per Minute.
Natoma No. 1......	11' 6"	50'	112'	104'	35'-6"	20'	150	3840	13½	61	64	20
Natoma No. 2......	9'	42' 8"	105'	92'	31'	25'	150	2395	8½	66	50	20
Natoma No. 3......	9'	42' 8"	105'	92'	37	25'	75	2395	8½	73	50	20
Folsom No. 3......	10'	42' 7"	120'	100'	37'-6"	20'	200	2276	8½	79	50	18
Folsom No. 4......	10' 3"	44' 7"	102'	90'	24'	20'	175	3258	13½	69	50	18
Folsom No. 5......	10' 3"	44' 7"	110'	142'	49'-6"	26'	75[1]	2163	8½	79	50	18
Folsom No. 6......	10' 3"	46' 6"	120'	145'	54'	30'	80	2534	8½	85	50	18
Yuba 9-10-11-12	9' 4"	44'	133'	....	60'	....	....	....	7½	94	..	..

Dredge.	Screens. Type, Shaking or Revolving.	Size.	Perforations. Upper Section	Perforations. Lower Section	Pumps.[3] Screen Supply.	Auxiliary Supply.	Monitor.
Natoma No. 1......	S	Upper 10' 10" x 22' Lower 11' 8" x 22'	⅜ to ½"	½ to ⅝"	14" V.-H. P.	10" V.-L. P. 3" V.	....
Natoma No. 2......	R	6' x 35' 6"					....
Natoma No. 3......	R	6' x 35' 6"	⅜ to ½"	½ to ⅝"	10" V.-H. P.	10" V.-L. P. 3" V.	....
Folsom No. 3......	R	7' x 36'	⅜ to ½"	½ to ⅝"	14" V.	8" V. [2]5" V.-2 S.	8" V.-3 S.
Folsom No. 4......	S	Upper 12' x 16' 5" Lower 12' 9" x 22' 6"	⅜ to ½"	½ to ⅝"	16" V.	5" V.-2 S.	....
Folsom No. 5......	R	7' x 36'	⅜ to ½"	½ to ⅝"	14" V.	5" V.-2 S. 4" V.	8" V.-3 S.
Folsom No. 6......	R	7' x 36'	⅜ to ½"	½ to ⅝"	12" V.-H. P.	12" V.-L. P. 5" V.-2 S.	12" V.-3 S.
Yuba 9-10-11-12	R	5' x 33'			10" V.-H. P.	10" V.-L. P. 4" V.	....

[1]Waste used for irrigation.
[2]Volute; high pressure; low pressure; two step.
[3]Hopper pump.

John Tyssowski, Eng. and Min. Journal.

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AMERICAN SPIRAL PIPE WORKS

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Products

Spiral Riveted Pipe.
Lap-Welded Steel Pipe.
Heavy Lap Welded Steel Tanks.
Hydraulic Supplies.

Taylor's Spiral Riveted Steel Pipe

(Sizes 3″ to 42″) suited for water supply lines. Lengths up to 40 ft. Galvanized or asphalt coated. The helical seam makes it 30 to 50% stronger than other pipe of the same thickness. Its enormous bursting strength, combined with lightness of weight, makes it especially advantageous for mining work. Forged steel connections used throughout.

HOMESTAKE MINING COMPANY

Lead, South Dakota, December 15th, 1921.

American Spiral Pipe Works.

Gentlemen:—

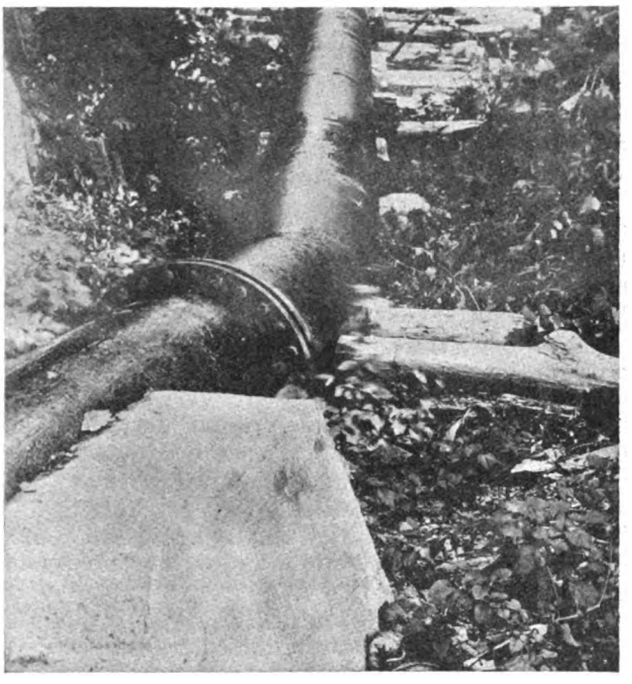
Answering your letter of the 6th inst. we beg to advise that the 12″, 14″, 16″, 26″ and 28″ Spiral Riveted Pipe, purchased from you during the years 1905 and 1906, has been in continuous service since purchased and proven very satisfactory.

Truly yours,

R. G. WAYLAND,
Ass't. Superintendent.

Lap-Welded Steel Pipe (Forge Welded)

(Sizes 12″ to 96″ dia., ¼″ to 1½″ thickness.) Specially suited for Hydro-Electric installations, dredging work, vacuum and suction lines. Made of best quality Open Hearth Steel by our forge welding process, resulting in a uniform weld of approximately 95% of the original plate, free from sweat leaks under the highest pressures.



Lap-Welded Pipe Line at Britannia Mining Co., Britannia Beach, Canada, Under 470 Lbs. Pressure

After four years of service they write:

"Our experience with your lap welded pipe is satisfactory to date.

Among the Large Users of Our Piping Are:

Old Dominion Copper Mining and Smelting Co., Globe, Ariz.
Homestake Mining Co., Lead, S. D.
Calumet and Hecla Mining Co., Calumet, Mich.
Chino Copper Co., Hurley, N. M.
Yukon Gold Co., Yukon Ter.
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General Executive Offices: SEATTLE, WASH., U. S. A.

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Portland, Ore., Lewis Bldg.
Denver, Colo., Mining Exchange Bldg.
Spokane, Wash., Hyde Bldg.
Tacoma, Wash., Box 1404.

Successors to

Pacific Coast Pipe Co.
Washington Pipe & Foundry Co.
National Tank & Pipe Co. (Pipe Dept.)
Portland Wood Pipe Co.

Operating Plants in

Seattle, Washington, and Portland, Oregon.

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WOOD PIPE

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OUR ENGINEERING DEPARTMENT IS AT YOUR SERVICE

Products

Continental Continuous Wood Stave Pipe.
Continental Wire Wound Wood Pipe.
Continental CREO-WOOD Pipe.
Continental CREO-WOOD Semi-circular Flume..
Continental Wood Tanks.
Continental Steam Pipe Casing and Conduit.

Materials Used in Manufacture of Continental Wood Stave Pipe and Flume

Only selected Douglas Fir is used. This lumber is straight and clear—free from knots and imperfections. Trees from which it is sawed attain immense diameters—several men ofttimes must join hands to encompass a single tree.

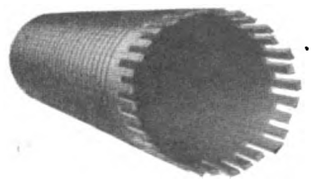
As much attention has been given to bands and wire as the wood. Bands are made from especially specified mild rolled steel of very high tensile strength. Shoes are the special design of this company.

Wire is specially made—an extra heavy steel wire for pipe purposes—heavily galvanized. The large diameter of the wire and its heavy galvanizing offers maximum protection against rust and acidulous mine waters.

CREO-WOOD pipe and CREO-WOOD flume are products developed and manufactured only by this company. The creosoting process of the staves was specially developed by us, and is a result of a long series of experiments.

Continental Continuous Stave Wood Pipe

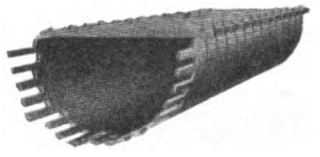
CONTINENTAL Continuous Stave Wood Pipe is made in any size, usually from 16 inches up to 20 feet in diameter. Staves are milled to the proper shape, banded with separate bands, spaced according to the pressure to which the pipe will be subjected. Bands have cast malleable iron connections or shoes and are threaded, so that the staves may be drawn tightly together. Material will be furnished and pipe constructed in place. Used in the mining world for hydro-electric development and water conveyance. Designed and built for heads of 400 feet in the smaller sizes and from 150 to 200 feet in the larger sizes.



Continental Continuous Stave Wood Pipe

Continental Continuous Stave Creo-Wood Flume

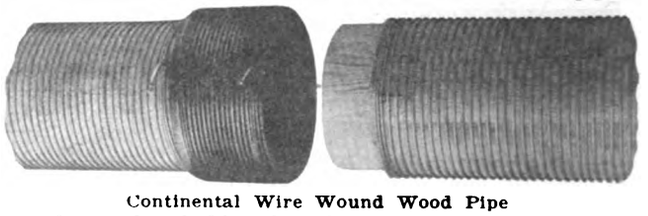
CONTINENTAL Semi-Circular Continuous Stave Creo-Wood Flume is a comparatively recent development, conceived and built solely by this Company. Staves and other primary parts are treated by the special pressure creosoting process developed by this Company. The success of this type of flume—the pronounced superiority of it over any other type has already won for it the unqualified endorsement of leading hydraulic engineers. Has greater capacity than any other type of flume—built on the continuous stave pipe principle—a sound guarantee of permanency. Used in the mining world for hydro-electric developments and water conveyance. Built in sizes from 18 inches to 30 feet inside diameter.



Continental Continuous Stave Creo-Wood Flume

Continental Wire Wound Wood Pipe

CONTINENTAL Wire Wound Wood Pipe is made in sizes of from 2 inches to 32 inches inside diameter—in convenient lengths, usually from 8 to 20 feet, and for heads as high as 450 feet. This pipe is banded with heavily galvanized round steel wire of high tensile strength, wound spirally around the pipe under machine-developed tension to draw the staves firmly together. The banding is spaced according to the head under which the pipe is to be used. This pipe is manufactured and shipped ready to lay, and is put together in place with couplings made in the same manner as the pipe. The couplings for the pipe, up to 12 inches in diameter, are banded similarly to the pipe. For the larger sizes, the couplings are banded with separate steel bands, the same as the continuous stave wood pipe. The untreated pipe and couplings are coated on the outside with a thick asphaltum coating. All collar couplings are given our standard CREO-WOOD pressure and vacuum creosoting treatment. Used in the mining world for smaller hydroelectric development and water supply and conveyance; also widely used for mine drainage.



Continental Wire Wound Wood Pipe

Fittings

This Company manufactures and can furnish all kinds of cast iron fittings for wood pipe. These may be shipped with the pipe—the tariff allowing 10 per cent of the minimum car weight to be shipped with the pipe at the same freight as the pipe.

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Main Office, 2098 McCormick Bldg., Chicago, Ill.
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EXPORT COMPANY—A. F. THANE & CO.
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Manufacturers of Redwood Lumber for Pipe

Product

Redwood Lumber—a non-resinous, soft wood, permeated during growth with an odorless natural preservative, protecting it from rot, decay and fire, and making it highly valuable for making wood pipe for conveying water, chemicals or sewage. Redwood's extensive use as a pipe material has proved it to be the superior product for use in mining, irrigation and chemical projects.

Uses For Redwood Pipe

In mines, where drainage water is not only hot, but also carries mineral and chemical solutions, which are detrimental to other kinds of wood, or to metal.

Conveying water for mining water supply.

Conveying water for fire protection systems.

Irrigation and conveying water on farms.

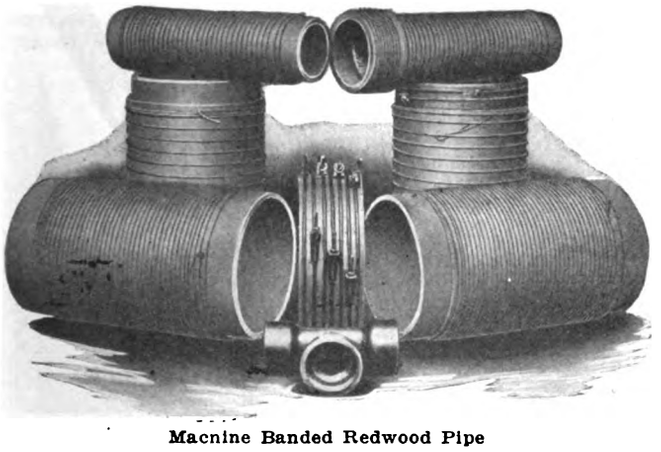
Conveying mineral and acid water in chemical plants.

Supply lines for municipal water distribution.

Machine Banded Redwood Pipe

This pipe is made in completed sections, and is shipped, ready to be laid.

The pipe sections are of standard lengths, from 6 feet to 24 feet. Diameters are from 2 inches to 32 inches.



Machine Banded Redwood Pipe

The staves are made of carefully selected, well seasoned Redwood, and milled to the circular outline of the pipe, both inside and outside. They are then assembled and wound with heavy galvanized pipe winding wire under heavy tension, the sizes varying according to the pressure.

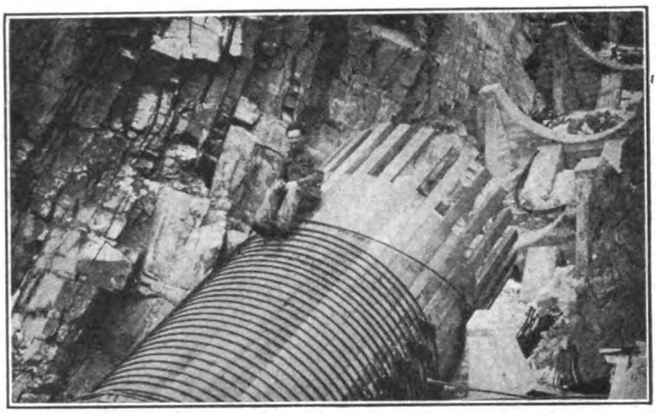
In laying Redwood machine-banded pipe the sections are simply driven together with a maul or ram.

Machine banded pipe can be made with a guarantee to withstand a static pressure of 800 feet. There are lines in Nevada carrying 500 feet head, which is 216 pounds to the square inch.

Continuous Stave Pipe

This is a "built-up" type, the staves being shipped to the operation, and there assembled and bound round with metal hoops.

Continuous stave pipe lines may be from 10 inches up to the largest size in diameter,—sometimes up to 16 feet in diameter.



Continuous Stave Pipe

Staves are made from clear heartwood, of straight grain stock. They come in standard sets, 6 to 9 feet and 10 to 20 feet lengths. Both ends of each stave are "grooved" or "splined" to admit a metal spline. The staves are arranged in "staggard" form, and provide a continuous pipe line, best adapted for long lines, carrying large volumes of water.

Redwood continuous stave pipe lines can handle, in large pipe, a pressure head of about 350 feet. In smaller diameters, pipe can be installed with sufficient strength to carry a pressure head of 400 feet.

Comparative Advantages of Redwood Pipe

Costs less for material, transportation and installation.

No expansion joints required, as Redwood will not expand nor contract with heat or cold.

Will survive many replacements of metal bands or wire hoops, even though they are heavily galvanized or asphaltic coated.

No "temperature cracks" as in cement or concrete pipe.

Will not freeze under a temperature that will burst metal pipe. If water freezes the flexibility of Redwood will prevent bursting.

No accumulation of blisters or foreign substances to impede flow of water.

Lasts longer than any other pipe except iron.

Not attacked by worms or insect life,—not even by the notorious white ant of tropical countries.

Unusual resistance to acids and alkalis in water or earth.

Water will remain cool, even when pipe is exposed to sun's rays on account of the non-conductivity of wood.

No discoloration of water contents.

No "tainted taste" to water contents.

Utility and Life of Redwood Pipe

Many Redwood stave pipe lines have been in use for from 20 to 35 years,—original installations made as far back as 1886 show no appreciable signs of decay. They are now in practically as good condition as when installed nearly 35 years ago.

NOTE—See Page 716 for information on production facilities, stocks, shipments and sales offices, etc.

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JOSHUA HENDY IRON WORKS

ESTABLISHED 1856

General Sales Offices
63-75 Fremont Street, SAN FRANCISCO, CALIFORNIA
Manufacturing Plant—Sunnyvale, Santa Clara Co., California

Designers and Manufacturers of

Mining, Milling and Industrial Machinery

Hydraulic Machinery Division

Owing to the limited space alloted for this subject in this volume prices, weights and detailed information are purposely omitted. Catalogs are available and inquiries are solicited.

The original and the longest established concern in the world featuring machinery required in the operation of Placer and Hydraulic Mines.

Hendy Giant using 2,000 mi. in. under 610 ft. head and moving 400 cu. yds. of earth and gravel per hour.

Hendy Hydraulic Giants

In hydraulic mining the systematic use of the Hendy Giant is well known and it is of interest to note that the excavation and transportation of earth, gravel etc. by hydraulic means has a far wider field of utility than is generally supposed.

The giant was originally limited to mine operations, then the advent of quartz milling was accompanied by the risk of fire. With the presence of ample water and sufficient head, Giants were placed as "Monitors" or "Fire-wardens," thereby effectively safeguarding danger from fire. The demand for fire monitors continues, and we build a special type for that duty.

The Hydraulic Giant is used to strip off the blankets of detritus from the croppings of auriferous veins. In Florida and Georgia the GIANT is, at a comparatively nominal expense, uncovering phosphate and kaolin preparatory to removal by steam shovels and scrapers. "Hendy" Hydraulic GIANTS are again found on the iron ranges of Minnesota and Michigan removing the overburden where the glacial drift has covered the ore bodies from a depth of 50 to 100 feet of sand associated with pebbles and rocks up to 3 inches and over. In municipal engineering it has found extensive application to level off sand hills and reclaim swamps with the fill. In railroad work it has been used both for excavating cuttings and making large embankments to replace high wooden trestles. A notable instance is recorded where clay, mud and sand were disintegrated by Giants and pumped from within a large cofferdam of sheet piling, where dredging was impossible in the effort to reach secure foundations for a seawall or quay. The Panama Canal is a noteworthy example of the uses to which Giants were adaptable. The Hydraulic Giant was used not only in excavating for foundations for the Miraflores lock-site, but also for the reclamation of land in the vicinity of Corozal, as well as in removing the sliding material which caused so much difficulty in Culebra and Cucaracha. Here, the GIANT sluiced the overburden into the Canal, where dredges pumped the now disintegrated mass through long pipe lines to fills and swamp lands, thereby further establishing the GIANT as essential, effective and commanding in many engineering problems hitherto untried or, perchance, unknown.

Another form of the "Hendy" GIANT is part of the equipment of the modern dredge used in gold and tin mining in Alaska, and in California and elsewhere for spreading tailings after having been piled by the dredge, or in disintegrating clay or cemented gravel where the banks require undercutting.

Hendy Hydraulic Gravel Elevators

consist of a device for utilizing the "suspending power" of a very high velocity ascending column of water acting in an enclosed pipe to elevate solid material, sand, mud, gravel, boulders and small rocks, from a low point on bed-rock to a height sufficient to obtain grade for sluices or dump. They consist essentially of an intake or entrance box, containing the "jet," a throat where the pressure energy of the "jet" is transferred to develop the ascending velocity flow in the mine up-raise pipe with discharge hood.

Diagrammatical Illustration of a Hendy Hydraulic Elevator

The proper proportioning of the respective diameters of the jet throat and upraise pipe, to give the correct velocity of "lift" and to avoid losses, is of the very utmost importance. The special merit of hydraulic elevators as against centrifugal sand and gravel pumps, is the fact that as there are no moving parts and no sharp deflections of the moving streams of gravel, there is practically no wear, no delays and no stoppages, and while the power or mechanical efficiency is not always as high as the best pumps, the actual working efficiency is as near perfect as can be. Elevators can be buried under a slide of mud and gravel, and will pump themselves clear, providing the pressure-supply pipes have not been actually displaced. This is where they have entirely superseded gravel pumps for all placer mine operations.

For this reason, even when natural head of water is not available, it is sometimes preferable to develop "pressure water" by high duty centrifugal pumps, and use this for the jets and employ "elevators" for the actual work of lifting the gravel. Although the combined mechanical efficiency of such a combination is low, the complete freedom from breakdown more than compensates.

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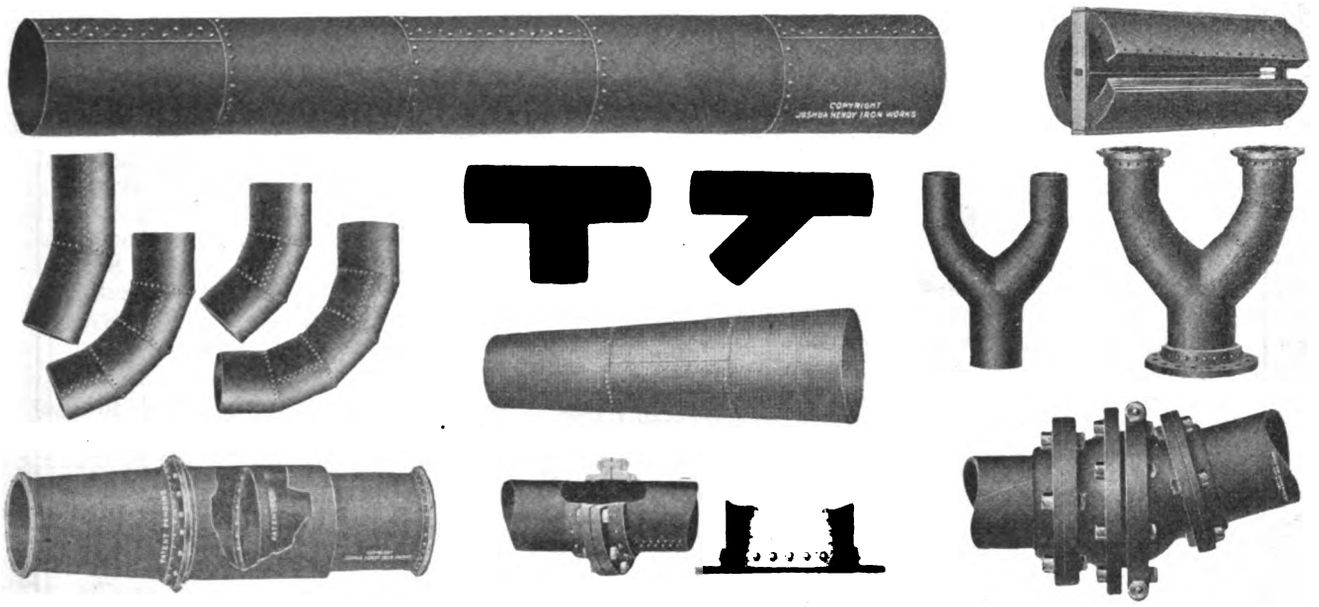
HYDRAULIC MINE MACHINERY

Products in This Line Include:

Riveted Sheet Steel Pipe and Fittings, Asphaltum coated, with and without flanges, in suitable lengths for shipment anywhere or cut, punched and formed for transportation by native carriers or pack-animals. Riveted pipe for pontoons or hydraulic dredgers. Expansion Joints and Ball Joints.

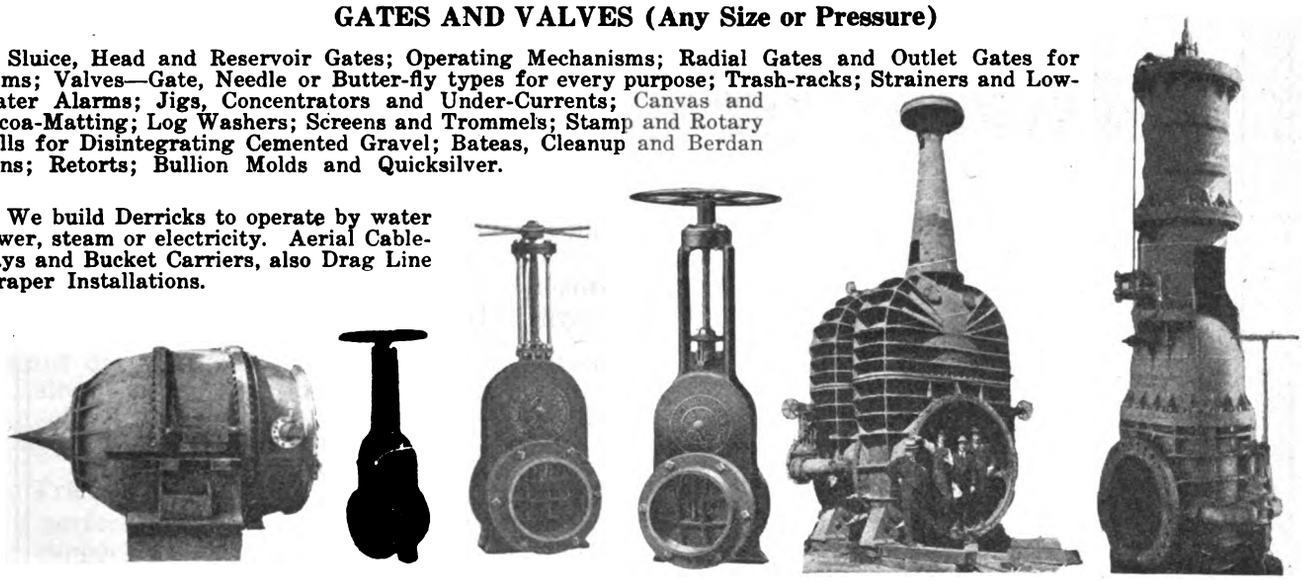


In addition to the above we manufacture in variety steel flumes, sluices and penstocks, likewise iron and steel riffles for saving gold and carrying debris.

GATES AND VALVES (Any Size or Pressure)

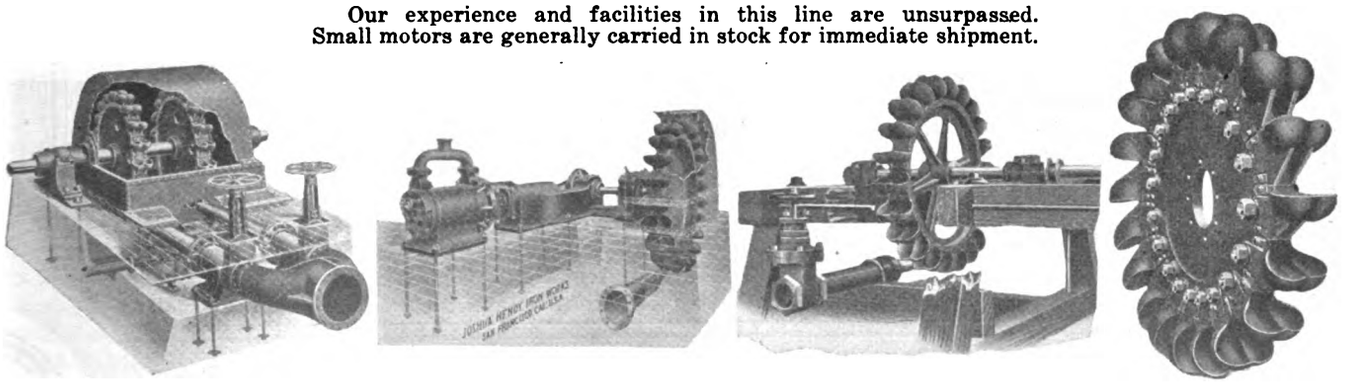
Sluice, Head and Reservoir Gates; Operating Mechanisms; Radial Gates and Outlet Gates for Dams; Valves—Gate, Needle or Butter-fly types for every purpose; Trash-racks; Strainers and Low-Water Alarms; Jigs, Concentrators and Under-Currents; Canvas and Cocoa-Matting; Log Washers; Screens and Trommels; Stamp and Rotary Mills for Disintegrating Cemented Gravel; Bateas, Cleanup and Berdan Pans; Retorts; Bullion Molds and Quicksilver.

We build Derricks to operate by water power, steam or electricity. Aerial Cableways and Bucket Carriers, also Drag Line Scraper Installations.



WATERWHEELS (Tangential Type)

Our experience and facilities in this line are unsurpassed. Small motors are generally carried in stock for immediate shipment.



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SECTION XV

Lubrication

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Cook's, Adam, Sons
Standard Oil Company (Indiana)

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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LUBRICATION DATA

In the operation of most machinery two kinds of friction have to be overcome by the expenditure of power: Solid friction, which results from actual contact of the moving surfaces, and fluid friction, which is due to the resistance the lubricant offers to motion. Since solid friction is much greater than fluid friction, lubricants are used to separate the moving parts of machines, and so substitute fluid friction for solid friction. With smooth bearings at high speeds and under moderate pressures, the substitution is practically complete with a suitable oil, and the friction developed is proportional to the true viscosity of the oil.

Solid Friction

More or less solid friction results where the lubrication is deficient either in quality or quantity. On account of the minute irregularities of bearings and journals, and on account of the tendency of metals to weld under the pressure, the resistance to motion is high where the metals are in actual contact.

The effects of solid friction are relatively large power losses, heating of the bearing, lowering of the viscosity of the oil by heating, and wear. As the bearings may be continually roughened by the sliding contact, the conditions become ideal for increased frictional losses. In most cases, the effect will be continued wear and continuous waste of power through excessive solid friction. With good lubrication, serious abrasion is entirely absent, and wear and solid friction are reduced to a minimum.

Solid and Fluid Friction

While for heavy, slow-moving machines, solid friction is generally an important factor in power consumption, in the usual bearings and journals at normal speeds and pressures, relatively more power is used in overcoming resistance to oil. If the lubricant does not keep the bearing and journal apart almost entirely during normal running, there is something wrong with the lubricant or the bearing.

Fluid Friction

In perfect lubrication, the moving part is entirely supported or "floated" on a film of oil which is of sufficient thickness to keep the journal and bearing apart under all reasonable conditions. To maintain such a film, the oil must have sufficient viscosity or "body." Pressure, speed, working temperature, condition of the bearings and method of oil feed determine the most advantageous oil to use, the effect of these different factors being as follows:

(1) With other conditions the same, high pressures require oils of higher viscosities than do low pressures, as high pressures tend to squeeze the oil from between the friction surfaces.

(2) With the same pressures, a fast-moving journal can be satisfactorily lubricated with a thinner or less viscous oil than can a slower journal. This is because the speedier journal sucks or pulls more oil in between the moving parts and so aids in maintaining the film.

(3) For bearings that operate at high temperatures, as on electric motors, an oil of greater viscosity is required than for lower working temperatures under similar speeds and pressures. Raising the temperature greatly reduces the viscosity of an oil.

(4) For rough bearings, an oil of high viscosity is required in order to maintain a thick film which will reduce actual contact of the bearing and journal to a minimum.

(5) With a circulating oil feed, or force feed, oil of lower viscosity can be used on account of the increased amount of oil reaching the bearing, which partly compensates for the oil squeezed out. The excess of oil also tends to reduce the temperature of the oil film and cool the bearing so that the working temperature is lower and the working viscosity is higher than where less oil is fed.

In general, for low pressures and high speeds a thin oil is desirable; for high pressures and low speeds, a thicker, more viscous oil is necessary. Pressure per square inch is meant, not the total pressure on the bearing, while speed refers to the friction speed of the contact surfaces and not to the actual rate of rotation. For rubbing speeds of less than 100 feet per minute, the oil film does not form properly for satisfactory oil lubrication.

With good lubrication, or practically perfect lubrication, the friction is chiefly fluid friction, and the main factor in determining the amount of friction is the viscosity of the oil, so far as lubrication is concerned. Obviously then, an oil which has just sufficient viscosity to carry the load under all reasonable conditions, but no greater viscosity, is the ideal lubricant.

Viscosity

By the viscosity of an oil is meant its internal friction or its resistance to flow. It refers to the same property as do the terms body and cohesion. For true liquids viscosity varies inversely as fluidity. The viscosity of an oil is its most important property from a lubrication standpoint. The coefficient of friction has been shown to be proportional to the true (absolute) viscosity of oils at the temperature of use.

The commercial methods of taking viscosity are based on the time required for a given volume of the oil to flow through a certain size opening or tube under specified conditions. The apparatus used to determine viscosity is called the Viscosimeter. The real importance of the viscosity determination has been obscured by the fact that determinations have been made at temperatures which did not represent the working temperatures, and by the fact that with commercial viscosimeters, the opening is made too large, or the tube too short, for thin oils to register their true relative viscosities as compared to the thicker oils.

Oil Lubrication

Successful oil lubrication is based on two fundamental principles:

(1) The use of an oil of sufficient viscosity to maintain a film of adequate thickness under normal

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working conditions plus sufficient additional viscosity to prevent bearings coming in contact during abnormal conditions. Since solid friction is so much greater than fluid friction, if bearings come together appreciably, power will be used up and more or less wear result. A lubricant which does not keep away solid friction and wear does not meet the primary requirements of a lubricant.

(2) The use of an oil of only sufficient viscosity to meet the above conditions, as all additional viscosity results in the useless consumption of power. At high speeds, not only can an oil of lower viscosity be used, but any additional viscosity results in much greater power losses than would result at lower speeds. Fluid friction is roughly proportional to the square root of the viscosity of the friction surfaces.

Imperfect lubrication with solid friction results where friction speeds are too low, or too little oil is fed, or the load is too great for the viscosity of the oil under working conditions. Consequently for heavy shafting where the friction speeds are low, and in similar circumstances with other machinery, an oil of sufficiently high viscosity should be used. If the speed is low, a reasonable excess of viscosity will result in little lost power.

Bearings

The design and fit of bearings greatly influence the quality of the lubrication. Bearings should be so constructed, by proper grooving or otherwise, and by proper location of the oil feed, that ample oil is drawn in or sucked in by the moving journal. In order to secure the best possible conditions for lubrication, the bearings should be smooth and of softer metal than the journal. While an excessively soft bearing would not offer sufficient resistance to the load, a soft bearing soon beds or flows to fit the journal so as to support the load at all points.

The area of bearings is designed to secure proper load per unit area. The area of the bearing should be just sufficient to maintain the load successfully under all conditions with the grade of oil used, as any excess area will increase the friction loss unless a thinner oil is substituted. For high speeds, the friction is practically independent of the load and proportional to the area of the friction surfaces.

The proper fit of bearing for the lowest coefficient of friction is obtained by having the radius of the journal slightly less than the radius of the bearing to give space for the oil film.

Grease Lubrication

Good lubrication with oils is difficult to attain with slow-moving machines under high pressures on account of the tendency of the lubricant to squeeze from between the friction surfaces faster than it is fed in by the motion of the journal. Since greases do not squeeze from bearings readily, but maintain a relatively thick film under pressure even when the journal is still, they are especially suited for slow or intermittent work where the loads are heavy. Sometimes oils of high viscosity can be used successfully for such work. For use on gears, greases are especially adapted, as the unit pressures are high and the rubbing speeds slow.

Greases are not suitable for high friction speeds on account of their greater frictional resistance as compared to oils, though they do not offer excessive resistance to flow at low speeds. The coefficient of friction is higher for greases than for oils, which is another way of saying that greases offer more resistance to motion than oils do. Thin greases and greases of low melting point do not offer as great frictional resistance as stiff greases of high melting point.

Graphite as a Lubricant

Flake and amorphous graphite have been widely used in conjunction with oils and greases for lubrication. The function of the graphite seems to be to build up the depressions in the friction parts, and so make a smoother bearing. The effect is to reduce the friction, to make possible the use of a much thinner oil and to reduce the consumption of lubricant. For very heavy work and slow speeds, graphite is extremely valuable in preventing abrasion and seizing, and for reducing solid friction, as in steam valves and cylinders.

Graphite also seems to form a veneer or coating which carries heavy loads without offering much resistance to motion. Only very finely divided graphite should be used, especially with bearings having small clearance. Very small amounts of graphite give the best results.

Mica as a Lubricant

In general, the action of mica in a suitable state of fineness is similar to the action of graphite in being a surface evener. Mica has been used largely in certain greases.

Advantages of Petroleum Lubricating Oils

The advantages of petroleum lubricating oils over animal and vegetable oils are the lower cost of the mineral oils, the non-oxidizing and non-gumming character of mineral oils and their general stability, and the great range of viscosity obtainable. This wide range in viscosity of the products available makes a knowledge of the viscosity of various mineral oils not only desirable but necessary to meet different lubricating conditions. The chief disadvantages of mineral oils consist in the non-adherence of the oils in presence of hot water and in the rapid decrease of viscosity under heat. Animal and vegetable oils also lose viscosity rapidly under heat. By proper attention to the temperature at which an oil is to be used, a mineral oil can be obtained which will meet all viscosity requirements at the desired temperature.

Gravity Tests

The gravity test has been accorded too much weight in judging the lubricating value of oils, consequently oils have often been found unsuitable because some more vital test, as viscosity, has been sacrificed to meet an impractical gravity requirement. The gravity is of value in judging the type of crude from which oil was refined. Thus high viscosity oils do not run over 30° Be., unless from Pennsylvania or similar crude. For a given crude the viscosity is generally proportional to the gravity, but this is not necessarily true for oils of the same type from different crudes.

It has long been a trade custom to use the Baume gravity (Be.) instead of the specific gravity. The simplest way to take the gravity is with a hydrometer. Hydrometers are made which read either degrees Baume, or specific gravity, or both. Since the gravity must be taken at 60° F., or be corrected to 60° F., hydrometers may be equipped with a thermometer.

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Flash Test

The flash point of an oil is the lowest temperature at which the oil gives off sufficient vapors to form an inflammable mixture with air. The flash point varies with the conditions of testing and with the apparatus used.

The flash point does not indicate the value of an oil for lubricating purposes, except in a very general way. Thus very high flash oils, such as cylinder oils, must usually have a high viscosity, and light oils, such as spindle oils, cannot have as high flash points as engine oils.

The chief value of the flash test is to determine the safety of an oil with respect to the fire risk and as an indication of the freedom of the oil from excessive evaporation loss during use. The fire hazard of lubricating oils is of importance where the oils are for use on fast-moving machinery, such as spindles, or for use in compressors for air, ammonia and other gases. The flash test is of special importance in connection with motor and other oils exposed to high temperatures.

There are a large number of different testers on the market for the flash test, but in the United States the open tester is used. A simple tester may be made from an open dish heated by a flame so that the temperature rise is from 10° to 12° F. per minute. The bulb of a thermometer is entirely submerged in the oil, but not allowed to touch the bottom of the dish. A small test flame is applied every 7° F., beginning at least 50° below the supposed flashing point of the oil. The flash point is the temperature read at the moment the vapor ignites with a slight flash. The heating may be continued, applying the flame as before, until the oil vapor continues to burn after the test flame is removed. The temperature observed is called the burning point or the fire test.

Fire Test

The fire test is the lowest temperature at which the oil gives off sufficient vapor to continue to burn after the vapor is ignited. Oils, particularly steam cylinder oils, have been largely sold by their fire test, which is from 40° to 50° F. above the flash test for motor or engine oils and from 60° to 80° F. above the flash test for cylinder oils.

Vaporization Test

The amount of oil that will vaporize at any given temperature is somewhat proportional to the flash and fire tests of the oil. A low flash oil will lose weight faster than a high flash oil.

The vaporization test gives more definite information as to the extent of the loss by vaporization under definite conditions than can be inferred from the flash and fire tests. This is especially true where the oil tends to decompose under the influence of heat. The usual procedure is to use temperatures of 212° F. or higher, up to the flash point of the oil, for a period of not more than 6 hours, the temperature used and the time of heating being chosen with reference to the type of oil and the condition under which the oil is to be used.

This test is of value in determining what flash test to specify, as for spindle oils or motor oils, and for testing such oils as air-compressor oils, turbine oils, transformer oils and superheater cylinder oils. In these tests the condition of the residue is of more importance than the actual loss on evaporation.

Cold Test

The cold test is the lowest temperature at which the oil will still flow. Methods of making the test vary and the temperature found has many names besides the cold test, such as the cloud test, pour test, flow test, chill point, freezing point and settling point. The oil does not solidify as a whole, but becomes solid from the freezing out of some constituent, such as paraffin.

The cold test is valuable where oils are to be exposed to low temperatures, such as on freight cars in winter and for use on pneumatic tools. In general, a lower cold test is required in winter than summer. For general lubrication the cold test should be sufficiently low to give a free flowing oil under the most severe service conditions, otherwise serious trouble may result from freezing of the oil.

The cold test has no special bearing on the lubricating value of an oil except at low temperatures. The cold test of western oils is naturally lower than the cold test of Pennsylvania oils on account of the freedom from paraffin.

Color and Appearance

The color of an oil is no indication of its lubricating value. Heavy oils have deeper colors than light oils, such as the paraffin oils or non-viscous neutrals. Oils should not be darker than their viscosity warrants, as such a condition is evidence of incomplete or improper refining. Highly filtered oils are paler than other oils of corresponding viscosity, but the color of oils can be lightened by acid treatment.

Red engine oils should be clear when viewed toward the light in a sample bottle. Oils should be free from any turbidity which might indicate the presence of water, paraffin, glue or other impurities.

Cylinder oils, if free from tar, are green in color instead of black.

All mineral oils show more or less "bloom" or fluorescence unless the bloom is artificially removed by the addition of nitro-benzene (oil of mirbane), or by nitro-naphthalene.

Emulsification Test

For oils used in circulating systems where the oil must be used repeatedly, such as in steam turbines, the oil must be able to separate from water readily and retain this property during use. The tendency to emulsify seems to be related to the presence of certain sulphur compounds, soaps and fatty oils or organic acids. The most important single test for a turbine oil or similar oil, after the viscosity test, is the emulsification test. The thickening of an oil in service prevents proper circulation and lubrication, and failure to separate from water makes an early rejection of the oil necessary.

TYPES OF OILS

Paraffin Oils

These oils are manufactured by fire distillation (without steam) and are decolorized or bleached by treatment with sulphuric acid. The final colors are yellow or red. Some of the better grade products are filtered instead of acid treated. The gravity seldom goes above 30° Be. even for the thinnest oils, and the viscosity is low compared to the gravity, as the method of distillation tends to break down the more viscous portion of the oil.

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The viscosity ranges from that of heavy kerosene to 300 at 100° F. The light oils can be used for spindle oils in place of the usual non-viscous neutrals. The heavy oils are used for engine oils, loom oils and motor oils. These oils are not so expensive as are neutral oils. The high viscosity paraffin oils are made by "reducing," that is, by distilling off the lighter oils by steam and fire.

Neutral Oils

These oils are manufactured by steam distillation and are of high viscosity in proportion to their gravity. After the wax has been removed from the mixed lubricating oil distillate, the oil is reduced by steam distillation to remove the lighter oils. These light oils constitute the non-viscous neutrals, while the residue from this final distillation constitutes the viscous neutrals.

The non-viscous neutrals usually have a gravity above 30° Be. and a low viscosity, suitable for light spindles. These oils are considered the best spindle oils, as they do not stain like paraffin oils if properly filtered. These oils are not usually acid treated. The viscosity is 46 to 65 at 100° F.

The viscous neutrals are usually slightly above 30° Be. and have viscosities ranging from 80 to 200 at 100° F. These oils are suitable for motor oils, turbine oils, gas engine oils, air-compressor oils and for the highest grade service. The color is reduced by repeated filtration through fuller's earth instead of by acid treatment. In order to make heavier oils, the viscous neutrals are blended with small amounts of high flash, filtered steam cylinder stock. Blended oils of high viscosity may have gravities as low as 27° Be., even when from Pennsylvania stocks, in which case the gravities will be much lower and the viscosities much higher than can be obtained from Pennsylvania distillates alone.

Engine Oils

Commercial engine oils are usually the heavier paraffin oils. The heavier oils are nearly always red, but the amount of color depends on the amount of acid treatment or of filtration. The color is not an index to the lubricating quality. The heavier engine oils may be built up by the addition of cylinder stocks to heavy distillates. Viscous neutrals were formerly much sold as engine oils, but high-gravity neutrals now go largely into the motor oil trade. Low-gravity western neutrals are still sold as engine oils. For circulating oil systems, neutral oils are more satisfactory than paraffin oils, as they separate from water better.

Motor Oils

For lubricating gasoline engines of all kinds, the viscous neutrals are considered most suitable. While Pennsylvania products are generally given preference, oils can be made by the same process from other crudes with equal success. For western oils, the gravity is lower and the viscosity may be higher. The heavy motor oils are made by the addition of special steam-cylinder stocks to viscous neutral oils. Paraffin oils make less desirable motor oils.

Turbine Oils

These are similar to the lighter motor oils. The neutral oils separate from water better than do the paraffin oils, and so are more desirable in actual service.

Air-Compressor Oils

These are similar to the lighter motor oils.

Cylinder Stocks (Steam Refined)

By steam distillation of Pennsylvania oils and other paraffin-base oils, a heavy undistilled oily residue is left in the still. This can be used as a cylinder stock after removing some of the solid impurities. Steam refined stocks of high fire test (over 600° F.) are not filtered, as filtration is difficult and the high temperature has removed most of the paraffin. The flash test ranges from about 550° to 600° F., and the fire test from 600° to 700° F. Low fire test stocks are more likely to contain paraffin, and high test stocks to contain tarry matter. Cylinder stocks should be free from tar, so the color should be green or brown and not black.

The viscosity of Pennsylvania stocks runs from 140 to 280 at 210° F. for the steam refined stocks. The highest viscosity Pennsylvania stocks do not run below 24° Be. in gravity.

Cylinder Stocks (Filtered)

Steam refined stocks can be cut back with crude gasoline and filtered through fuller's earth or boneblack to remove carbon and coloring matter. The highest fire test stocks are never filtered, the fire test of filtered stocks rarely being over 600° F. Also stocks of over 160 viscosity are rarely filtered. Pennsylvania stocks do not run less than 26° Be. Filtering reduces the viscosity of cylinder stocks.

Bright stocks are generally low cold test stocks made in the preparation of petrolatum.

Blended Oils

Blended oils are made by mixing mineral oils, either distillates or cylinder stocks. Sometimes oils are cut back by the addition of a small amount of a low viscosity oil to reduce their viscosities. An example would be the addition of a distillate to a cylinder stock to lower its viscosity or the addition of a distillate to car oil to change a summer car oil to a winter car oil. Sometimes the viscosity of light oils is built up by the addition of heavy oils, as in adding cylinder stocks to engine oil distillates to make heavy motor oils.

In mixing or blending oils it is well to remember that the viscosity of the mixture is always decidedly lower than would be calculated from the viscosities of the two oils and the proportions taken. Where the oils are very different in viscosity the variation from the expected viscosity is greatest. The viscosity of the mixture may be as much as 30 per cent. below the expected viscosity, but is usually from 5 to 15 per cent. lower than the calculated. The gravities are as would be expected, but the flash point is lower than the mean of the mixture.

Compounded Oils

Compounded oils are made by mixing or blending a mineral oil with a fatty oil. The chief compounded oils are cylinder oils, made by dissolving animal or other fatty oil in cylinder stocks, and marine engine oils made by dissolving rape oil or blown rape oil in mineral oil. Compounded oils for other purposes are now seldom used. The viscosity of a compounded oil is much less than the theoretical viscosity calculated from the oils used in compounding.

Cylinder Oils

Cylinder oils are made by compounding (mixing) cylinder stocks with animal or vegetable oils. Cylinder stocks are never used alone for lubricating

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saturated steam cylinder except where the condensed water is to be used again for some purpose, and are rarely used alone for lubricating superheated steam cylinders, at least in America. A certain amount of fixed oil (fatty oil) is necessary to keep the wet steam from displacing the oil from the friction surface of the cylinders and valves. A straight mineral oil will not form or maintain an oil film on metal in the presence of hot water, that is, it will not wet the metal, and so will not lubricate. Fatty oils will wet metal in the presence of hot water and they have the property of keeping this valuable characteristic even when mixed with mineral oils.

Varying amounts of fixed oils are required, ranging from 2 to 12 per cent. or over, the lower per cent. being sufficient for very dry steam and the higher per cents. being required for very wet steam, as is present in low-speed cylinders. The usual cylinder oils contain less than 12 per cent. of fatty oil, the amounts ordinarily present being 4 to 10 per cent.

Practically all kinds of animal and vegetable oils have been used at times for compounding cylinder oils. The most generally preferred is tallow oil, but neatsfoot oil, lard oil, degras, degras oil, rape oil, blown rape oil, cottonseed oil and even linseed oil have been used. The animal oils are preferred on account of their non-gumming character. Rape oil is popular abroad, and blown rape oil is used, as it has a high viscosity which makes the viscosity of the compounded oil not much lower than the viscosity of the stock from which it was compounded. The addition of fatty oil lowers greatly the viscosity of the cylinder stock to which it is added, even more than would be expected.

Excessive amounts of fatty oils, above that actually required, should not be added to cylinder stocks, as the fatty oils break down somewhat under the action of steam, forming free fatty acids which attack the metal of the cylinder. Carefully compounded oils do not give any trouble in this particular.

The oils used for compounding cylinder oils should be acidless, as acidless tallow oil; that is, they should contain less than 2 per cent. of free acid calculated as oleic acid.

If the exhaust steam is to be condensed and used over again, it is important that the amount of fatty oils be reduced to a minimum, so that the oil can be separated from the water readily. This is true in the case of cylinder oils for ice plants and for marine engines, which are often operated with straight cylinder stocks.

It may be said that the high viscosity cylinder stocks have better adherance to hot, wet metal than have lower viscosity stocks, and so require no more fixed oils than do cylinder oils for lower pressures. The high-flash, high-viscosity oils are more difficult to atomize, but proper location of steam pipe and proper installation of the lubricator will result in good atomization with the higher pressure steam.

For superheated cylinders, oils are compounded from high fire test, high-viscosity stocks and 3 to 11 per cent. of animal oil, usually tallow oil. As much as 11 per cent. is not usually required for stationary engines, but may be in locomotive practice on account of greater condensation from cooling in winter or to make possible the lubrication of the low-pressure cylinders of compound engines with the oil carried by the exhaust steam from the high-pressure cylinders. The viscosity of the finished oil is rarely as low as 140, and is usually between 160 and 220 at 210° F. Cylinder oils for saturated steam have viscosities from 100 to 220 at 210° F.

Filtered cylinder oils are not usually required for either saturated or superheated steam cylinders.

Analyses of Some Cylinder Oils (Lockhart)

No. of Oil	1	2	3	4	5	6	7	8	9	10	11	12
Kind of Oil	Pasty Filtered Stock	Bright Filtered Stock	Bright Filtered Stock	Steam Refined Stock	Filtered R. R. Superheater	Filtered R. R. Saturated	Dark Low Pressure	Low Pressure	High Pressure	Special Low Pressure	High Pressure	Special Low Pressure
Baume gravity	22.0	23.1	26.2	25.6	25.5	26.0	27.0	22.5	24.5	25.0	22.4	22.6
Flash test (°F.).....	550	510	545	585	535	530	485	530	570	455	550	525
Viscosity at 150° F...	...	458	435	...	...	406	281	465	696	341	666	463
Viscosity at 210° F...	183	138	141	168	180	128	100	141	220	115	187	136
Fatty oils (%).....	1.5	0.4	2.6	0.9	11.2	10.6	9.5	3.6	5.3	3.3	7.0	4.3

Car Oils (Black Oil, Reduced Oil, Well Oil)

The residue left after distilling off the lighter lubricating oils by fire distillation is a black oil which is sold in the unrefined condition as car oil. For winter car oil, the distillation can be stopped earlier, or the residue can be cut back with some light distillate.

The viscosity of winter black oil is high enough for summer use, so far as actual lubrication of the journal is concerned, but a higher viscosity oil is required in summer so as to feed properly by means of the waste. The friction loss is greater with the heavier oil than it would be with the lighter winter oil.

Analyses of Car Oils (Lockhart)

Sample No.	1	2	3	4	5
Kind of Oil	Summer Car Oil	Summer Car Oil	Winter Car Oil	Winter Black Oil	Black Engine Oil
Gravity (° Be.)....	21.4	20.0	25.7	27.4	24.0
Viscosity at 210° F.	80	95	65	66	61
Flash point	....	400	375	....	....
Sediment	....	Very dirty and tarry	Little Sediment	Black Sediment	Black Sediment

It has been customary to specify the viscosity of car oils at 130° F., instead of at 210° F., but the tendency is to depend more on the figures at 210°.

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The cold test of summer oil is not important, but the cold test of winter should not exceed 10°. except for southern climates. Tarry matter should not exceed 5 per cent. This includes all sediment. The gravity is not important, as the cost is an important consideration and specifying gravity would make some users go to distant fields to meet the specification. The viscosity for winter oil should be between 60 and 65 at 210°., and for summer oil 80 to 100 at 210° F. The flash point should be above 250° F. in winter for northern climates and over 325° F. in summer; for southern climates the flash point might advantageously be 50° higher for each instance.

LUBRICATING GREASES

Greases are used for lubricating bearings where the pressures are too great for successful oil lubrication; for lubricating difficultly accessible parts of machines; for preventing undesirable splashing; for preventing waste of lubricant from poorly housed bearings; and for reducing the cost of lubrication by reducing the attention required and the amount of lubricant fed to the bearings.

Greases are made in varying consistencies, or in varying degrees of hardness, to suit different purposes, from the soft compression cup or rod cup greases to the solid greases used for journals.

Composition of Some Greases (Gillette)

Kind of Oil	Graphite	Summer Motor	Winter Motor	Auto	Tallow A	Tallow XX	Lead Rosin Oil	Lime Rosin Oil	Soda Grease	Non-Fluid Oil	No. 4 Petrolat.	Lard Oil
Flash point (°C.)	195	160	175	190	210	215	240	198	215	210	247	265
Melting point (°C.)	93	87	86	79	52	49	102	77	83	76	47	5
Consistency (20°C.)	18	170	7	11	150	200	7	31	35	27	6	0
Water (%)	Trace	Trace	Trace	1.0	2.5	Trace	24.7	Trace	0	0	0	0
Calcium soap (%)	11	38	23	19	...	30	...	...	...	9.8	...	...
	Graphite				Potash	Soap	Lead Soap	Ca O	Soda	Soap		
Other Thickeners (%)	16	...	...	...	1.4	2.1	1.7	9.9	22.0	12.9	...	...
Mineral oil (%)	56	36	40	60	22	20	...	...	78	70	100	...
Fatty oil (%)	17	25	37	20	73	48	0	0	0	7	0	100
Free acid (%)	0	Trace	6.1	Trace	0	0	0	0	0	0	0	...
Max. rise in bearing temp. (°C.)	53	39	42	32	22	25	40	42	17	25	16	7
Aver. Coefficient of Friction	0.097	0.075	0.063	0.046	0.022	0.029	0.067	0.048	0.019	0.026	0.018	0.011

The most usual type of lubricating grease today is the soap-thickened mineral-oil type. Practically all the greases met with in general lubricating practice are made by combining mineral oils of different grades with varying amounts of lime soaps, soda soaps, or other soaps. The texture of these greases is influenced by the character of the mineral oil, the kind of soap (as soda or lime), the amount of soap, the kind of fatty oil from which the soap was made, by the presence of free fatty oils, by the presence of water in the grease, and by the process of manufacture.

Cup Grease

Cup greases are nearly always lime-soap greases, from 12 to 23 per cent. of lime soaps being present, combined with a mineral oil distillate of low or medium viscosity. The general practice is to use very thin oil, which may not give enough lubricating body to the grease for heavy work. Water is generally present from traces up to 1 per cent. The small amount of emulsified water, usually less than 0.4 per cent., is added to give the proper consistency to the grease and to prevent ultimate separation of the lime-soap and the mineral oil. The effect of much water is to make the grease softer, so excessive amounts of water are seldom found since the addition of the water is not economical to the manufacturer. Water also makes the grease opaque and lighter in color.

In making cup greases it is important that only sufficient lime be used to saponify the fat or fatty oil used, otherwise the grease will contain free lime which might attack some kinds of bearings, e. g., brass bearings. There should be no uncombined fatty acids in the grease, but fatty oils have only a beneficial effect on the bearings in the absence of fatty acids.

The cup greases, or lime-soap greases, are somewhat more generally used than the soda greases. Cup greases are often blended with graphite or mica. This may or may not be good practice, depending on the amount and the nature of such additions and the purpose for which the grease is to be used. For heavy machinery, mica and graphite are often advantageous, though the tendency is to use excessive amounts.

Soda Grease

These greases are made by dissolving soda soaps in hot mineral oils. Heavier oils are generally used than in the cup greases, although light oils are also used. The oils used are paraffin oils, engine oils and cylinder stocks. Soda greases have a better reputation than lime-soap greases on account of the presence of heavier oils and on account of the freedom from any tendency to separate into soap and oil. Where soda greases are free from water they can be melted and cooled down without separation.

The soda greases are generally known as "fiber" or "sponge" greases, on account of their peculiar texture.

Gear greases or gear compounds are soda greases or sponge greases in which the soap is of a stringy character and the oil is a heavy, dark oil or cylinder stock. On account of the viscous nature of the oil these greases show good adhesive properties and a good cushioning effect.

Analyses of Greases (Lockhart)

Kind of Oil	Medium Cup Grease	Cup Grease	No. 3 Cup Grease	Soft Comb-Box Grease	Rod Cup Grease	Transmission Gear Grease
Flash point (°F.)	365	345	355	360	305	540
Melting point (°C)	83	85	83	77	...	High
Water (%)	0.4	Trace	Present	0	0	0
Lime soaps (%)	19.7	21.2	13.4	0	7.5	0
Soda Soaps (%)	0	0	0	2.3	0	12.5
Fatty oils (%)	2.4	9.1	...	0	0	0
Gravity (° Be.)	...	...	...	25.2	28.2	...
Gravity of oil (° Be.)	27.7	...	...	...	31.4	25.6
Viscosity of oil (100°F.)	104	...	...	...	58	High

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For special purposes, some of the stiff, heavy soda greases may contain up to 50 or even 60 per cent. of soaps for heavy bearings or journals carrying heavy loads. Soda greases should not contain any uncombined caustic. Ordinarily, however, there is no special difficulty involved in making a neutral product. Greases should not be stiffer than absolutely necessary, as stiff greases use up power to a marked extent.

Non-Fluid and Soap-Thickened Oils

The non-fluid oils or solidified oils are made by combining from 0.5 to 7 per cent. of suitable soaps (lime, aluminum, lead or soda soaps, alone or mixed,) with light mineral oils, such as paraffin oils. These treated oils vary in consistency from the soft pastes used for rod cups down to thick oils. Mineral castor oil is made by dissolving from 2 to 5 per cent. of aluminum soaps in a light paraffin oil, the effect being to give a stringy character to the oil and greatly increase its apparent viscosity. The real viscosity of such oils can be determined at low temperatures without first removing the soap.

Thickened oils and grease pastes or jellies have many advantageous applications, as they can be made of fairly low melting points for use in cups where a slight increase in temperature will cause them to flow to the bearing. One of the special uses is for non-splash oils.

Axle Grease

This grade of grease is usually made from lime and rosin oil, with or without the addition of mineral oil. The lime combines with the acids in the rosin or rosin oil, forming a "soap" which thickens the oil so as to form a grease. Usually more lime is used than is required to combine with the rosin acids, the excess lime remaining as a filler. Mica, talc, soapstone and other powdered substances are also added to this grade of grease. Axle grease is only suitable for rough work, such as use on iron bearings.

Rosin consists mainly of organic acids and is soluble in hot petroleum oils. Rosin oil, made by distilling rosin at a high temperature (above 360° C.) contains up to 40 per cent. of organic acids. The oil high in acids is most suitable for grease making. The method of manufacture is either to stir the dry slaked lime into cold rosin oil and let it "set" without any further stirring or agitation, or to make a cream of slaked lime with water, this cream being stirred into the rosin oil. In this latter case the water is expelled during the setting of the mix and mineral oil is then stirred in after running off the water.

Rosin greases usually contain either small amounts of water or about 20 per cent. of water.

LUBRICATION OF VARIOUS MACHINES

Stationary Gasoline Engines

The oil used should ordinarily have a flash test of about 400° F., and should preferably be a straight distillate (viscous neutral). This mineral oil distillate may be blended with a very small amount of filtered cylinder stock, for use with heavy engines. Distillation of the oil should therefore show very little carbon residue unless the oil is for extra large engines which require an extra heavy oil. The gravity is preferably, but not necessarily, above 26° Be., though oils of any gravity may be used successfully if of proper viscosity. Oils which turn black on heating to their flash points for 15 minutes or show considerable sediment on subsequent settling will tend to form excessive amounts of carbon in use. All oils show some darkening when heated to high temperatures.

Medium oils of 220 to 270 viscosity at 100° F. are suitable for small gasoline engines. For large gasoline engines heavy oils of 250 to 450 viscosity should be used. For engines operating in cold climates the cold test should be sufficiently low to meet practical conditions. Engines having force feed can use the higher viscosity oils to advantage, while the high viscosity oils are required for air-cooled engines.

Dynamos and Motors

Most of these machines are equipped with ring-feed bearings, or with circulating feed. The usual conditions are high speeds and a fairly high operating temperature due to the heat generated by the electric current in the adjacent coils. The function of the oil is to give sufficient lubrication and to aid in cooling the bearings. Since the oil is used over and over again, a thin oil is decidedly preferable. Such an oil circulates more readily and permits the impurities to settle out more quickly.

Where the oil-cooling reservoir is not sufficiently large an oil of higher viscosity becomes necessary. Such an oil is more likely to form gummy material and give trouble than would a thinner oil kept at the proper temperature by an efficient cooling system. In starting a dynamo or motor, particularly the larger machines after long standing, the bearings can often be hand-oiled to advantage. The oiling rings should be regularly inspected to see that they are revolving and so feeding the oil properly.

For lubricating the bearings of very small machines heavy spindle oils or non-viscous neutral oils can be used. These oils should have a viscosity of 70 to 110 at 100° F.

For dynamos and small motors, of 5 to 35 horse power, viscous neutral oils are required. Engine oils of good grade and light automobile oils are suitable. The oils should preferably be straight distillates purified by filtration rather than by chemical treatment, and of low enough cold test to meet ordinary conditions of use. The gravity of the best oils will ordinarily be above 30° Be., but good oils can be had of 27° Be. The flash point will be above 380° F., the cold test below 20° F., and the viscosity 140 to 180 at 100° F. The oils should be free from gummy or tarry matter, as shown by the gasoline test.

For large dynamos and motors, over 50 horse power viscous neutral oils of 160 to 220 viscosity at 100° F. are suitable. These oils should be preferably straight distillates, have a flash test of 400° F., and be pure mineral oils, as shown by the tests just given for purity.

Transformer Oil

The function of a transformer oil is to act as a non-conductor, chiefly between the primary and the secondary coils, and to carry off the large amount of heat generated by reason of the electrical resistance in the coils. To be able to maintain the proper dielectric conditions, the oil must

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be absolutely free from acid, alkali and mineral salts, and free from any trace of moisture or mechanically suspended impurities.

Even one part of water in 100,000 parts of oil greatly reduces the dielectric strength of the oil. For use in high tension transformers the oil is subjected to a test of 30,000 volts. The suspended water is usually removed by filter-pressing; for example, through several hundred thicknesses of blotting paper. Water can also be removed by filtering through freshly burned lime. A simple method for testing for the presence of water in the oil is by shaking the oil with a little anhydrous copper sulphate. The white powder turns blue if there is a trace of moisture present. The anhydrous copper sulphate can be prepared for use by gently heating a little of the ordinary blue copper sulphate so as to drive off the water. The presence of water in any appreciable amount can also be detected by heating a quantity of the oil in a test tube immersed in a boiling salt-water bath. If water is present in the oil a series of small bead-like bubbles will form on the surface of the oil where it is in contact with the tube.

In order to circulate freely the oil should be of low viscosity, preferably a non-viscous neutral of 80 to 120 or 140 viscosity at 100° F. The oil circulates by gravity or by means of a pump. The cold test should be below 20° F.

Since the oil is subjected to high temperatures almost continuously, up to 100° C., the flash should be over 340° F. The oil should not lose over 0.2 per cent. when heated at 100° C. (212° F.) for 5 hours, and should not contain asphaltic or tarry matter originally or after heating for several hours in the presence of air at 250° F. The gravity should be above 32° Be.

Rotary Converters

The same type oil, or slightly heavier oils, are used as for heavy dynamos and motors.

General Engine Lubrication

For lubricating the moving parts of steam engines, other than cylinders and valves, a good grade of engine oil should be used. This oil is preferably a straight mineral oil distillate of 400° F. flash test, 27° to 31° Be. gravity, and a viscosity of 180 to 250 at 100° F. For large engines with circulating oil systems, the viscosity need not usually be over 220 at 100° F., as an oil of lower viscosity can be used better with a circulating system which floods the bearings than without a circulating system, where the oil must be fed sparingly. The excess oil tends to cool the bearings and so maintain the viscosity of the oil.

As more or less water comes in contact with the oil, it is necessary to separate out this water in the oil-filtering process. A good quality of filtered oil should therefore be used, and it should be protected in every way from other contaminating oils. If an oil too high in fatty oil is used in the steam cylinder, some of this oil may finally work into the circulating oil supply and cause it to emulsify with the water to an objectionable extent. For large engine installations it is desirable that oils be tested for emulsification with water, and oil chosen which shows little emulsification.

Steam Turbines

Lubrication is usually by a gravity, or force-feed circulating, system which makes it possible to use a thin oil. High-grade, pale engine oils, known as viscous neutrals, are generally used. They should have a gravity of over 30° Be., be straight mineral oil distillates free from acids, and have a flash point around 400° F. Where an asphalt base oil is used the flash and gravity will not be so high. The oil should always be tested for its emulsifying properties, as the oil should separate readily from water in practice.

In order to continue to separate from water properly and maintain a suitable viscosity without the development of acidity, the oils should be practically free from sulphur. The nature of the sulphur compounds is important.

The oils should be non-carbonizing when tested, as for motor oils, and should be free from undistilled residue. In practice the amount of oil in the circulating system should be ample to prevent any great increase in the temperature of the bulk of the oil. Sulphur and continued high temperature of the oil tend to develop acids which would attack the bearings and cause emulsification. The maximum working temperatures are ordinarily from 130° to 140° F., but according to Herschel some of the more recent turbines run at 175° F.

The oils have from 120 to 170 viscosity at 210° F. The most important single test, after the viscosity test, is the emulsification test, which gives a better indication of the behavior of the oil in a circulating system than can be obtained by any physical or chemical tests.

Shafting Lubrication

For shafting a very heavy engine oil is necessary. Oils with a viscosity of 220 to 290 are suitable. Generally oils from 220 to 250 can be used with satisfactory results. Oils have been used with a viscosity as low as 140 at 100° F., but this is not to be recommended.

In order to prevent constant loss of power it is necessary that all shafting be aligned properly and lubricated thoroughly. The same oil can be used for shafting and for general lubrication, such as bearings and slides, but not for steam cylinder lubrication.

Air Compressors

On account of the great increase in temperature when air is strongly compressed, it is usual to compress in two or more stages with intermediate cooling. If no radiation or cooling took place air taken at 60° F. and compressed under 50 pounds pressure would have a temperature of 339 F°. Similarly under 100 pounds pressure the temperature would be 485° F., and under 150 pounds the temperature would be 580° F. But as cooling always occurs, the real temperatures run considerably lower.

On account of the high temperature, carbonization tends to take place, as in motor oils, therefore, compressor oils should be tested for tendency to carbonize, or for sulphur, which seems to influence the amount of carbonization. For safety the oil should have a flash point well above 400° F. Only straight mineral oil distillates of low cold test and high gravity (above 30° Be.) should be used. A low viscosity oil is generally preferred, from 160 to 200 for average pressures and 200 to 250 for high pressures. A simple test for comparing these oils is the amount of darkening or deposit (insoluble in gasoline) formed on heating to the flash point for several hours. There should not be much darkening or deposit.

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If the oil is too thick it adheres to the valves, where it carbonizes from the dry heat. It is important to use the minimum amount of oil and to use clean air. Low flash oils have caused a number of explosions, so the oils might very well be tested for amount of loss under heat.

Soapy water mixed with flake graphite is said to give good lubrication without causing sticking of valves, but it is necessary to feed oil just before shutting down to avoid rusting.

For air-cooled compressors, as on locomotives, the temperatures get very high (up to 450° F., or even 550° F. at times). For such compressors it is necessary to use cylinder stocks, or cylinder oils.

Pneumatic Tools

Pneumatic tools such as drills, operated by compressed air, require oils of very low cold test on account of the drop in temperature of the expanding air. The cold test should be below 10° F., the gravity above 30° Be., and the viscosity should be low as determined at 100° F.

Hoisting Ropes

Hoisting ropes (metal) are lubricated with coal tar containing up to 20 per cent. of lime to neutralize the tar acids. A mixture of tar and engine oil is used, alone or mixed with graphite, mica or talc. The tar aids in the exclusion of water and so prevents corrosion of the metal. Solid fats and waxes also are used with oils for the same purpose.

Mine Car Journals

For the journals of cars, summer black oil of 85 viscosity at 210° F., or winter black oil of 65 viscosity at 210° F. is generally used. The journals should be properly packed, should be inspected and cleaned regularly, and should be protected from all gritty material as much as possible. Clean, thin greases, called "black dope," are used to some extent for car journals.

Cutting Tools

The office of cutting oil is to cool the cutting tool and at the same time lubricate the face of the tool. The pressure on the cutting edge is great, and no lubrication is possible or desired at this point.

Mineral oils, such as kerosene oil or paraffin oils, can be used as cutting oils. They are more often compounded with 20 to 25 per cent. of fixed oil, such as lard oil or cottonseed oil, or even corn oil. Kerosene seems to work well on cast iron, but the presence of lard oil or some similar oil seems to make a cleaner, smoother and faster cut on steel and copper. The paraffin oil can be compounded with other fixed oil with similar results.

Emulsions of water, soap and mineral oils, with or without soda, are also used for cutting purposes. These so-called soluble oils are made by combining soluble soaps with light mineral oils, such as paraffin oils. The soaps may be made from fats, rosin, etc. The product emulsifies permanently, if properly made, when brought into contact with water. This emulsion is also made by dissolving a suitable soft soap in water and then stirring in a mixture of lard oil and paraffin oil. The presence of the oils and soap tends to reduce the amount of rusting which might be caused by the water. These water soluble oils are better cooling agents than pure oil products on account of the fact that the heat absorbing capacity of water is about twice as great as that of oils.

Special merit is claimed for the suspension of graphite in water known as "aquadag."

Where a purification system is used and the oils are available for re-use, the more expensive cutting oils can be used to advantage.

Compiled from Lockhart's American Lubricants.

TABLE OF GRAVITIES AND WEIGHTS OF PETROLEUM OILS

Degrees Baume (Modulus 140)	Specific Gravity 60°/60° F.	Pounds per Gallon	Gallons per Pound	Degrees Baume (Modulus 140)	Specific Gravity 60°/60° F.	Pounds per Gallon	Gallons per Pound
10.0	1.0000	8.328	0.1201	55.0	0.7568	6.300	0.1587
11.0	.9929	8.269	.1209	56.0	.7527	6.266	.1596
12.0	.9859	8.211	.1218	57.0	.7487	6.233	.1604
13.0	.9790	8.153	.1227	58.0	.7447	6.199	.1613
14.0	.9722	8.096	.1235	59.0	.7407	6.166	.1622
15.0	.9655	8.041	.1244	60.0	.7368	6.134	.1630
16.0	.9589	7.986	.1252	61.0	.7330	6.102	.1639
17.0	.9524	7.931	.1261	62.0	.7292	6.070	.1647
18.0	.9459	7.877	.1270	63.0	.7254	6.038	.1656
19.0	.9396	7.825	.1278	64.0	.7216	6.007	.1665
20.0	.9333	7.772	.1287	65.0	.7179	5.976	.1673
21.0	.9272	7.721	.1295	66.0	.7143	5.946	.1862
22.0	.9211	7.670	.1304	67.0	.7107	5.916	.1690
23.0	.9150	7.620	.1313	68.0	.7071	5.886	.1699
24.0	.9091	7.570	.1321	69.0	.7035	5.856	.1708
25.0	.9032	7.522	.1330	70.0	.7000	5.827	.1716
26.0	.8974	7.473	.1338	71.0	.6965	5.798	.1725
27.0	.8917	7.425	.1347	72.0	.6931	5.769	.1733
28.0	.8861	7.378	.1355	73.0	.6897	5.741	.1742
29.0	.8805	7.332	.1364	74.0	.6863	5.712	.1751
30.0	.8750	7.286	.1373	75.0	.6829	5.685	.1759
31.0	.8696	7.241	.1381	76.0	.6796	5.657	.1768
32.0	.8642	7.196	.1390	77.0	.6763	5.629	.1776
33.0	.8589	7.152	.1398	78.0	.6731	5.602	.1785
34.0	.8537	7.108	.1407	79.0	.6699	5.576	.1793
35.0	.8485	7.065	.1415	80.0	.6667	5.549	.1802
36.0	.8434	7.022	.1424	81.0	.6635	5.522	.1811
37.0	.8383	6.980	.1433	82.0	.6604	5.497	.1819
38.0	.8333	6.939	.1441	83.0	.6573	5.471	.1828
39.0	.8284	6.898	.1450	84.0	.6542	5.445	.1837
40.0	.8235	6.857	.1459	85.0	.6512	5.420	.1845
41.0	.8187	6.817	.1467	86.0	.6482	5.395	.1854
42.0	.8140	6.777	.1476	87.0	.6452	5.370	.1862
43.0	.8092	6.738	.1484	88.0	.6422	5.345	.1871
44.0	.8046	6.699	.1493	89.0	.6393	5.320	.1880
45.0	.8000	6.661	.1501	90.0	.6364	5.296	.1888
46.0	.7955	6.623	.1510	91.0	.6335	5.272	.1897
47.0	.7910	6.586	.1518	92.0	.6306	5.248	.1905
48.0	.7865	6.548	.1527	93.0	.6278	5.225	.1914
49.0	.7821	6.511	.1536	94.0	.6250	5.201	.1923
50.0	.7778	6.476	.1544	95.0	.6222	5.178	.1931
51.0	.7735	6.440	.1553	96.0	.6195	5.155	.1940
52.0	.7692	6.404	.1562	97.0	.6167	5.132	.1949
53.0	.7650	6.369	.1570	98.0	.6140	5.110	.9957
54.0	.7609	6.334	.1579	99.0	.6114	5.088	.1966
55.0	.7568	6.300	.1587	100.0	.6087	5.066	.1974

*Chicago Pneumatic Tool Company.

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ADAM COOK'S SONS

708-710 Washington St., NEW YORK, N. Y

Manufacturers of

Albany Lubricating Products

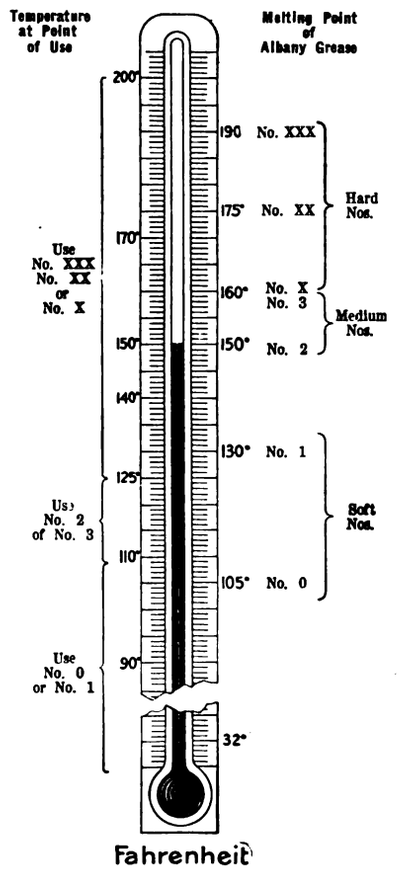
Products

Everything in the line of lubricants to meet regular and special requirements, purposes and conditions—including Albany Grease, Cook's Lubricant, Cook's Cup Greases and Albany Lubricating Oils.

A MARK known and respected around the world — Since 1868 — for fair dealing, a quality product and an unexcelled service.

Albany Grease

Albany Grease is a pure tallow cup grease. Unlike mineral-oil greases Albany Grease is sensitive to temperature changes. It has sufficient body to retain its firm consistency in the cup, under any condition of room temperature, but when the need of lubricant in the bearing causes friction and the temperature rises, the grease in the cup melts and feeds an amount just sufficient to maintain a condition of perfect lubrication. With the removal of the cause of bearing heat the grease in the cup immediately stops feeding.



This is why Albany Grease stands supreme in economy, and assures the highest lubricating efficiency. Feeds only as needed and is all consumed in doing useful work. There is no drip—no waste.

Because it is absolutely pure, Albany Grease does not deteriorate and cannot spoil in storage or shipment. It can be purchased in barrels and used to the last drop.

Albany Grease can be used in any grease cup or bearing cap, and is made in a full range of consistencies to afford a grade which will give fully satisfactory service under any temperature conditions—in a refrigerating room or over a boiler. It will save you from 25 to 80% of the cost of lubricating with average greases.

Put up in 5, 10, 25 and 50 lb. cans, kegs, half-barrels and barrels.

Cook's Lubricant

A pure mineral-oil grease, especially compounded for the lubrication of gears, chain belt drives, axle bearings of mine and industrial cars, the transmission and differential gears of motor cars, etc.

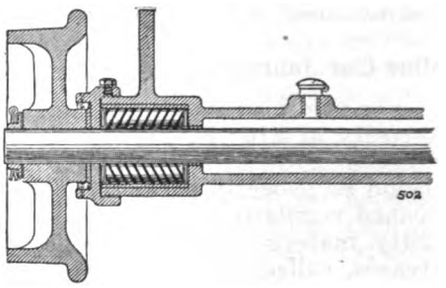
Cook's Lubricant possesses certain characteristics absolutely essential to such service—the unusual quality of adherence—it cannot be thrown off, no matter how high the speed.

It will not pack or channel, but closely follows gear-teeth and chain links, allowing them to engage easily, and always maintaining a cushion of lubricant between contact surfaces.

Made in three consistencies—soft, medium and hard—and packed in 5, 10, 25 and 50 lb. cans, kegs, half-barrels and barrels.

Mine Car Lubricant

Cook's Mine Car Lubricant (soft consistency) is the ideal means of cutting down lubricating costs, reducing friction and saving power. Cars require less attention and give longer service. You save a thousand times the cost of good lubrication in lessened depreciation.



Cook's Lubricant admits no superior for the lubrication of mine car axles, of either floating, roller-bearing or other type.

Cook's Cup Greases

Mineral-oil-base greases for general use where the service does not justify the use of the more efficient, but more costly Albany Grease. Made in a complete range of consistencies or densities.

Albany Lubricating Oils

All-Pennsylvania base oils, of low carbon content and high lubricating efficiency. Available in grades for steam and air cylinders, oil cups, ring oiled bearings and other uses, on all mine and mill machinery.

Reputation

Albany Lubricating Products have been friction's most consistent enemies since they were first manufactured—1868. They are noted for their quality, honest efficiency and dependability. We do not make the cheapest, but we do claim there are none superior.

They bring lower operating costs, less depreciation, and efficient continuous service. We invite your inquiries and will gladly help you solve your lubricating problems.

Albany Lubricating Products may be secured from reliable dealers or direct. We will furnish samples free of expense.

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STANDARD OIL COMPANY

(INDIANA)

910 So. Michigan Ave., CHICAGO, ILL.

Manufacturers of

Lubricating Oils and Greases

Products

Superla Mine Car Greases, Ario Grease, Omega Grease, Superla Cylinder Oils, Superla Steam Turbine Oil, Superla Engine Oils, Ario Compressor Oil, Superla Dynamo Oil, Superla C & G Compound.

Superla Mine Car Greases

Superla Mine Car Greases are made in three consistencies to meet the requirements of every make and type of wheel and axle in use on mine cars.

They are—

1. Superla 18 Grease
2. Superla 39 Grease
3. Superla 57 Grease

Superla Greases possess unusual lasting qualities. One filling will last from one to six months, depending upon the type of wheel, the condition of the wheel, and the service required of the car. Superla Greases are not affected by water. They are not affected by acid, or the gases that may be present in the mine. They effectively seal the bearings and protect them from outside action.

Superla Greases will not harden nor gum. They will not separate nor break down by continued pressure, but will allow a free rolling of the wheel. Superla Greases work readily in any type of mine car grease-gun.

Ario Grease

A very soft grease or non-fluid oil with good cold test, manufactured especially for the lubrication of valves and pistons of air operated tools, such as stopers, rock drills, jackhammers, etc. It will not blow out of working parts, yet it is free enough to feed in the presence of wet air or water, and keep the high speed, closely fitted parts working at the highest efficiency.

One filling of the air tool with this grease will lubricate it better, and four or five times longer, than ordinary grease, castor machine oils or black oils.

This grease is especially adapted for the lubrication of high speed silent chains, bearings subject to water conditions, or where excessive vibration throws off oil, also punches and dies on alloy steels.

Omega Grease

Slightly heavier in body than Ario Grease but having the same general characteristics. It is especially adapted for the lubrication of rock drills of the wet type and can readily be packed in the cartridge and grease receptacle which is used with some drills.

It also affords excellent lubrication for slow-speed, silent chains, comb boxes, cam shafts, shaker screens and vibrators, bearings subject to excessive vibration, eccentrics and rocking motions.

Superla Cylinder Oils

Superla brands of steam cylinder oils represent a complete line of steam engine, cylinder and valve lubricants of the highest order. These oils are made in grades suitable for any steam condition from low pressure to high pressure and superheat.

Superla Turbine Oil

A steam turbine lubricant which will reduce friction to a minimum. Does not emulsify nor mix with water. Has a very low rate of consumption. A light oil with very high lubricating value.

Superla Engine Oils

Made in grades suitable for any class of continuous circulating lubrication, or gravity feed cups; for engine bearings and general machine lubrication. Will separate readily from water and filter perfectly.

Ario Compressor Oil

Suitable for intermediate and high pressure air compressors of the plate valve or poppett valve type. The use of this oil will eliminate trouble from carbon deposits in compressor or receiver. It is very economical in use because it will go much further than ordinary air compressor oils.

Superla Dynamo Oil

Especially manufactured for all types of electric motor and dynamo bearing lubrication. The use of this oil will extend the life of these important bearings, needing less attention and less frequent renewal.

Superla C & G Compound

This product is a dark, adhesive compound especially developed for use on gears, cables and chains. It will not gum or pack on the gear teeth. Makes a suitable protection for wire ropes and cables.

Service

This company manufactures lubricants for all kinds of mine equipment. We maintain a corps of specially trained lubricating engineers who are able to determine the correct lubricant and devise the most economical method of its application to mine machinery. This advisory service is free and at the disposal of any mine regardless of size.

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SECTION XVI

Explosives and Blasting

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THE MINING CATALOG
CONSOLIDATED PUBLISHING COMPANY INC.

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

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FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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EXPLOSIVES

By Robert M. Black.*

It is natural to associate explosives with destruction, but their use in construction and upbuilding has been a large factor in the history of civilization. They have been essential in making the excavations for many railroads, canals, and buildings, they have assisted in agriculture, they have made quarry work easy, they have limited conflagrations and they have made possible economical mining.

Primitive mines appear to have been surface accumulations of gems or minerals, which were loosened with pointed sticks. The ancients later used alternate applications of fire and water to loosen the valuable mineral, or rock containing it. Such methods could not produce a quantity of mineral sufficient to meet the growing demands. Nor did the best of the early methods penetrate beyond very shallow depths, unless the material happened to be exceptionally rich and easy to work. While there are some substitutes for explosives now used in a limited way in mining practice, still the history of mineral production shows the dependence of the industry on explosives. Increased use has brought about improvements in composition, in facilities for use, in safety and in cost, most of which development has taken place within comparatively recent times. Explosives are to be credited not only with the large production of mineral generally, but also with the entire production of certain minerals that occur under conditions rendering them difficult or impossible of winning otherwise. Practically all the coal mined in the United States is broken from the seam by the use of explosives.

The oldest explosive is believed to be gunpowder, but the date of its invention and the name of the inventor remain uncertain. A document still preserved at Florence, Italy, relating to the manufacture of cannon, refers incidentally to gunpowder. The date, February 11, 1326, marks the first unquestioned reference to the use of gunpowder in Europe. Roger Bacon, the English philosopher, who lived in the thirteenth century, writes of a mixture composed of saltpeter, charcoal and sulphur in proportions similar to those of gunpowder, "producing noise like thunder and flashes like lightning". It seems to have been regarded at that time as a curiosity, and its applications to useful work were unknown. There is some reason to refer the invention of gunpowder back to more ancient time, when, according to the views of some, the Chinese, Greeks and other races had substances resembling it, but the evidence is by no means conclusive.

DESCRIPTION OF EXPLOSIVES

An explosive is defined as a substance capable of extremely rapid decomposition into a relatively large volume of gases under the action of either heat or shock. Combustion is the union of any element with oxygen, a familiar example of which is the burning of wood, the carbon of the wood uniting with oxygen to form gases. The gases in this case are formed slowly, and have abundant opportunity to pass off into the atmosphere without disturbance. If the rate of formation of the combustion gases is rapid, and if the volume of such gases is much greater than can be contained in the space formerly occupied by the combustible substance, then the pressure on the inside of the space containing the gases is so great that the enclosing material is ruptured and fragments are thrown to varying distances. The pressure is further increased by the heat of combustion expanding the gases formed.

Gunpowder

The essential feature of an explosive being the production of a large volume of gases from a small volume of the substance, materials have been sought that would give the most efficient results. While oxygen from the air is sufficient to support ordinary combustion, the supply is not great enough to produce the volume of gases necessary to do the work of an explosive. Some source of concentrated oxygen is, therefore, required, and for this purpose, saltpeter, or potassium nitrate (KNO_3), suggests itself. This substance is found in nature in various places on the globe, but it seems to have been observed originally in India, and for that reason is sometimes known as India saltpeter. The substance selected for the combustible was charcoal, which is composed chiefly of the element carbon. In the process of combustion, charcoal contributing carbon and saltpeter contributing oxygen, gases composed of carbon and oxygen atoms are formed, chiefly carbon dioxide (CO_2), but with some carbon monoxide (CO) where combustion is incomplete. The problem was to start the combustion. Carbon and oxygen do not unite at ordinary temperatures, but only at a high temperature. To obtain the heat most easily, sulphur was added to the mixture. Sulphur burns readily, and in doing so, produces a temperature sufficiently high to effect the union of carbon and oxygen atoms. The mixture described is known as gunpowder, because it was early applied to use in guns. The standard proportions for the ingredients are 75 parts potassium nitrate, 15 parts charcoal and 10 parts sulphur, all in terms of weight.

It is necessary that the ingredients be thoroughly mixed, in order that each particle of combustible may have as close to it as practicable a particle of oxygen. The nitrogen of the potassium nitrate is liberated as gas, and the potassium combines with the sulphur to form potassium sulphide (K_2S), a solid product, approximately one-third the volume of the gunpowder.

*Associate Professor of Mining University of Pittsburgh.

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Other nitrates than potassium nitrate might meet the requirements for supplying oxygen, and efforts have been made to find an efficient substitute, which would at the same time have the advantage of being cheaper. About 1870, sodium nitrate ($NaNO_3$) was first used, and found to be successful from these standpoints, where its property of absorbing moisture was not detrimental. As this substance came chiefly from Chile, it has been known as Chile saltpeter. For use in guns, the potassium nitrate powder is preferred, because it keeps drier, and therefore, in better condition for use after long periods of preservation.

Black Blasting Powder

For a blasting powder, either of the two saltpeters may be used, but the consideration of economy favors the sodium nitrate. Powders made from either saltpeter are known commonly by the name of black powder, or blasting powder, that containing potassium nitrate being usually designated by manufacturers as "A", and that containing sodium nitrate as "B". When sodium nitrate is used, the proportions of the mixture are slightly different, namely, 73 parts sodium nitrate, 16 parts charcoal, 11 parts sulphur. The difference is due chiefly to the fact that the oxygen content of sodium nitrate is greater than that of potassium nitrate. In each case, the intention is to provide just enough oxygen to consume the carbon and sulphur.

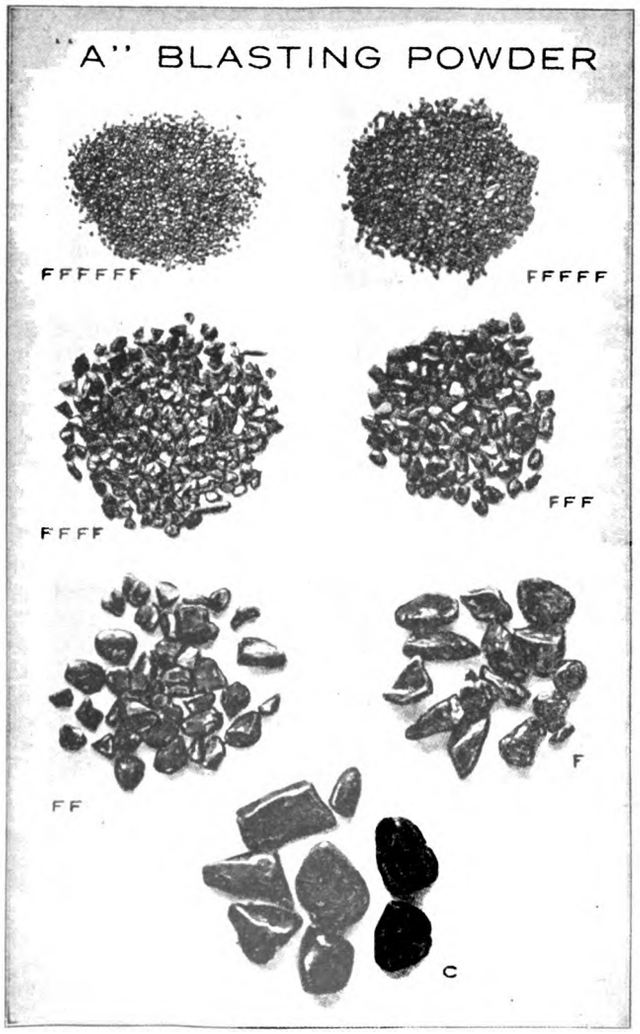

Fig. 1—Sizes of "A" Blasting Powder.

Blasting powder is marketed in granular form, "A" powder, Fig. 1, usually in seven different sizes, and "B" powder, Fig. 2, in the same number, each

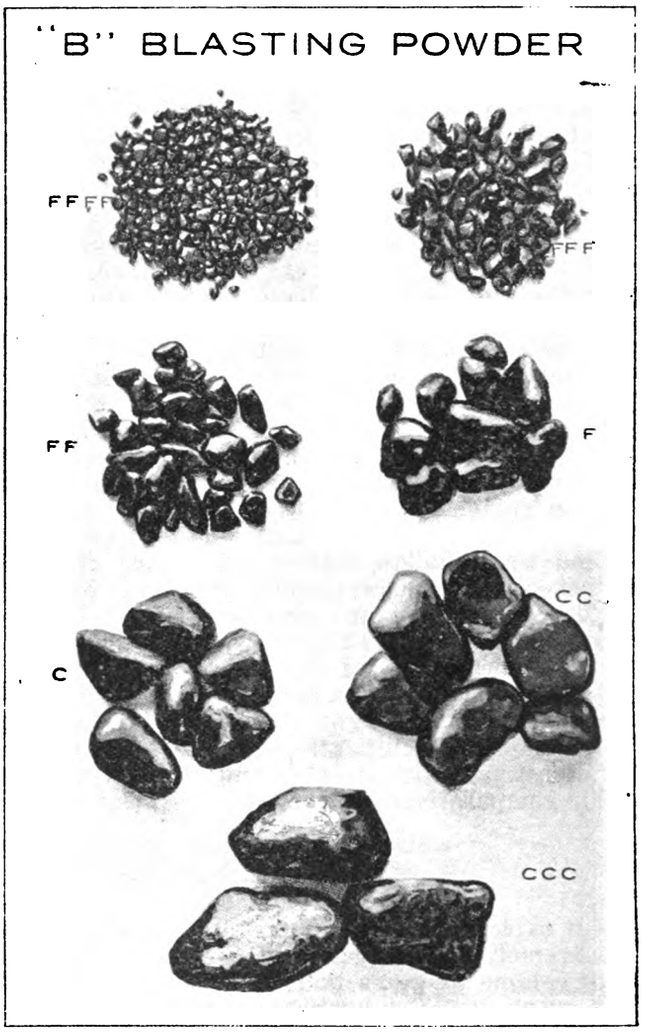

Fig. 2—Sizes of "B" Blasting Powder.

size being designated by one or more letters. In general, the sizes of "A" and "B" powders do not correspond, the "B" averaging larger than the "A".

The powder is packed in sheet steel kegs, usually of 25 pounds capacity, although the use of fibre for the material of the container is also in favor. The chief advantage of the latter is that it is a nonconductor of electricity, and is, therefore, safer for transportation in cars hauled by electric locomotives. If the powder is received in metal containers, it may be transferred to fibre containers, provided with bail handles and designed specially for such transportation. The latter are known as electrical pails, and are used for other explosives, as well as blasting powder. The same material has been employed in making powder flasks for the individual miner, these being of the maximum capacity permitted by law, usually five pounds.

The sizes of powder are carefully separated at the factory, and grains of one size only are shipped in one container. The chief purpose of this precaution is to insure, as far as possible, uniformity in rate of burning. If grains of different sizes were mixed, the smaller grains would burn more quickly,

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and tend to throw the larger grains in an unburned or incandescent state out of the hole. Under some circumstances, the result would be only a waste of the larger grains, but if explosive gas were present, as is often the case in coal mines, the danger of igniting it would be very great. Another advantage of uniform sized grains is the standardizing of results, which makes possible the selection of powders suited to certain requirements. The grains are usually glazed with graphite to render them more impervious to moisture. Fine grained powders are quicker, and tend to shatter the material more, while coarse grained powders are slower and have more of a lifting effect.

Chlorate Powder

Oxygen may be obtained from other compounds beside nitrates, and many efforts have been made to adapt such substances to use in explosives. Some success has been attained with potassium chlorate (KCO_3), but the liability of this substance to explode on slight friction has prevented its general use. Methods have been devised, however, of restricting this tendency by mixing with certain other substances, such as starch, and the results have been satisfactory.

Nitroglycerin

Oxygen may be made to unite chemically with certain substances by treating the substances with nitric acid (HNO_3). The nitric acid is manufactured from either of the saltpeters, and contains the same quantity of oxygen as the saltpeter. One substance frequently treated with nitric acid for this purpose is glycerin, $C_3H_5(OH)_3$, the result of the nitration being a compound known as nitroglycerin, $C_3H_5(NO)_3$. In this process, sulphuric acid is first run into nitric acid, then glycerin into this mixture, the heat of the reaction being dissipated by careful stirring and sometimes artificial cooling. The nitroglycerin formed is separated from the acid by pouring into cold water, and is then purified.

Nitroglycerin is a colorless, oily liquid with specific gravity about 1.6. It freezes at a temperature of about 55° F., and is evaporated by heating, but at 306° F., explodes by reason of the temperature alone. It is poisonous to the human system internally and externally, but the danger from contact poisoning diminishes with continued handling. It is exploded ordinarily by shock, and is very sensitive to shocks; therefore, is especially dangerous to handle. In the liquid condition, it is little used, but when associated with certain solid substances, its properties may be employed with reasonable safety. Nitroglycerin is among the most important of all explosives commercially.

There are two general classes of explosives, represented respectively by gunpowder and nitroglycerin, and known as low and high explosives on account of the difference between their effects. The same classes are known as deflagrating and detonating explosives, because of the manner of their ignition. High explosives are more rapid and more powerful than low explosives.

Dynamite

Nitroglycerin is used most in connection with an absorbent material, or dope, such as wood meal or infusorial earth, and the mixture is known as dynamite. Its specific gravity is about 1.4. Dynamite possesses the properties of nitroglycerin, but is safer to transport and handle than the liquid. Dopes may be inactive, as those mentioned above, or they may be active, and contribute to the explosion of the dynamite. An example of active dope sometimes used is gunpowder. Dynamite and other nitroglycerin mixtures are graded according to their strength by percentages of nitroglycerin, or its equivalent, present in the mixture. The usual range is from 15 per cent. to 60 per cent. For purposes of comparison, the United States Bureau of Mines has adopted as its standard straight dynamite a mixture of 40 per cent. nitroglycerin, 44 per cent. sodium nitrate, 15 per cent. wood pulp and 1 per cent. calcium carbonate.

For commercial use, dynamite is packed in paraffined paper cartridges, 8 inches long and usually 1¼ or 1½ inches in diameter. The cartridges are packed in wooden boxes, each containing 25 or 50 pounds.

The products of combustion of 200 grams of standard dynamite are stated as follows:*

PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE

	Grams.
Solid	79.7
Liquid (water)	14.5
Gaseous	88.4

Gaseous Products of Combustion

	Per cent. by volume.
Carbon dioxide	51.4
Carbon monoxide	5.0
Hydrogen	2.2
Methane	.3
Nitrogen	41.1
	100.0

Solid Products of Combustion

	Per cent.
Soluble (sodium carbonate)	79 43
Insoluble (calcium carbonate, trace of unburned carbonaceous matter, and carbonates and oxides of copper, iron, and tin)	20.57
	100.00

GASEOUS PRODUCTS OF COMBUSTION FROM 200 GRAMS OF THE EXPLOSIVE AND 12.4 GRAMS OF PAPER WRAPPER.

	Per cent.
Carbon dioxide	27.3
Carbon monoxide	26.9
Hydrogen	18.0
Methane	.4
Nitrogen	27.4
	100.0

Guncotton

If cotton is treated with nitric acid in a manner corresponding to the treatment given the glycerin, there results a substance, guncotton, or nitrocellulose, which is highly explosive. The chemical process is essentially a replacement of the hydrogen in the cotton by nitrogen and oxygen, this providing the oxygen necessary for burning the substance with explosive rapidity. Another high explosive, similar to guncotton in its composition and manufacture, is nitrostarch, made by nitrating starch.

Blasting Gelatine

A solution of guncotton in nitroglycerin makes a gelatinous substance, known as blasting gelatine, which is an extremely quick and powerful explosive, inasmuch as the carbon that would be left after explosion of the guncotton alone is consumed by the oxygen that would be left by the explosion of the nitroglycerin alone. The strength of blasting gelatine is rated at 100 per cent. The mixture of blasting gelatine with an absorbent dope is known as gelatine dynamite. Either form is considered to be especially suited to blasting under water.

Dynamite and other nitroglycerin mixtures must be thawed when frozen, because in the frozen

*Bulletin 15, U. S. Bureau of Mines, page 172.

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condition, they are less susceptible to detonation, but more susceptible to ignition by friction. By the addition of certain chemicals to a nitroglycerin mixture, the freezing point may be greatly reduced, and thawing rendered unnecessary. There are many such low freezing explosives on the market, but no claim is made for them that they will not freeze at any temperature.

Fulminates

One subdivision of the high explosive class, known as fulminates, is important on account of their application in igniting other explosives. They are prepared by first treating certain metals with nitric acid, and then the resultant solution with alcohol. This type of explosive is extremely sensitive to heat or shock. The metal most frequently used as the basis of a fulminate is mercury. The mercury fulminate is especially convenient for communicating to charges of dynamite or other high explosive the shock necessary for ignition.

Comparative Strengths of Blasting Explosives*

In the course of its investigations of blasting explosives, the U. S. Bureau of Mines (Bull. 48) has made tests to determine the potential energy, the disruptive effect and the propulsive effect of some of the explosives in common use. The potential energy was measured by means of the bomb calorimeter in water. The disruptive effect was measured, using the Mettegang recorder, detonating fuse, Trauzl lead blocks and small lead blocks. The propulsive effect was measured in the Bichel pressure gage and by means of the ballistic pendulum. The tabulated results are given herewith, together with the approximate composition of typical examples of the various explosives. The percentages figured are rated against the effect of 40% straight nitroglycerin dynamite taken at 100 per cent.

The figures are fairly consistent with general practice, and it is believed that the classification will serve as a useful guide for comparing the practical value of explosives. It is worthy of note that the potential energy of 40% strength ammonia dynamite and of 40% strength gelatin dynamite, that is, the theoretical maximum work that these explosives can accomplish, is higher than that of 40% straight nitroglycerin dynamite, but that the disruptive and propulsive effects, which represent the useful work done as shown by actual tests, are less. Accordingly, straight nitroglycerin dynamite is more economical for general use in blasting operations if the conditions and character of the work are such as to permit its use; nevertheless, the ammonia dynamite and the gelatin dynamite are more efficient and economical for certain kinds of work that require explosives having a large propulsive effect and a comparatively small disruptive effect. For example, in blasting soft rock, 40% straight nitroglycerin dynamite, which has a very high percussive force, may be too quick in action, whereas the ammonia dynamite or the gelatin dynamite having practically the same heaving and pushing action and less percussive force will be more suitable. The tests also show that 60% strength low-freezing dynamite is not quite equivalent to the 40% straight nitroglycerin dynamite. It is worthy of note that black blasting powder has little disruptive effect, only about one-third that of granulated nitroglycerin powder.

Means of Firing

The simplest means of firing is a squib, a thin paper tube, about 6 inches long, one end of which contains a core of meal powder and the other a slow match. After the cartridges are in position, a copper, or copper tipped, needle a quarter of an inch in diameter is pushed into the outer end of the charge, as shown in Fig. 9. About the needle the

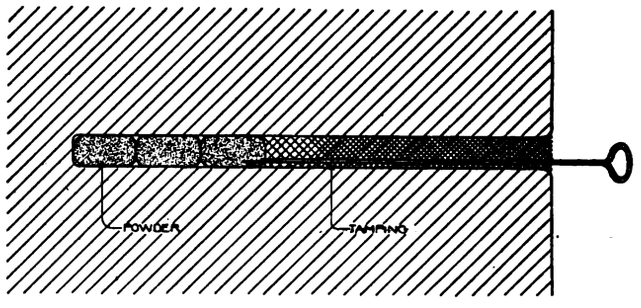

Fig. 9—Drill Hole, Showing Needle in Place.

clay tamping material is packed with a wooden bar. The needle is then withdrawn, leaving a passage of its own dimensions from the outside of the hole to the powder. Into this hole the squib is placed. After the match is lighted, Fig. 10, a brief interval elapses before the squib is projected forward like a rocket and its flame ignites the powder.

TYPICAL ANALYSES AND STRENGTHS OF COMMON BLASTING EXPLOSIVES*

	Percentage Composition								Percentage Strength		
	Nitro-glycerin	Combustible Material	$NaNO_3$	ZnO, $CaCO_3$, $MgCO_3$	Nitro-substitution Compounds	NH_4NO_3	Nitro-cellulose	S C	Potential Energy	Disruptive Effect	Propulsive Effect
Straight nitroglycerin dynamite, 30%	30	a17	52	1	..	..	..	.. ..	93.1	84.1	96.8
Straight nitroglycerin dynamite, 40%	40	b15	44	1	..	..	..	.. ..	100.0	100.0	100.0
Straight nitroglycerin dynamite, 50%	50	b14	35	1	..	..	..	.. ..	111.0	109.2	107.4
Straight nitroglycerin dynamite, 60%	60	b16	23	1	..	..	..	.. ..	104.0	119.8	114.9
Low-freezing dynamite, 40%	30	b15	44	1	10	..	..	.. ..	.....	.....	.....
Low-freezing dynamite, 60%	45	b16	23	1	15	..	..	.. ..	60.2	93.5	91.2
Ammonia dynamite, 40%	22	a15	42	1	..	20	..	.. ..	101.8	67.9	99.1
Gelatin dynamite, 40%	33	a13	52	1	..	..	1	.. ..	105.7	78.4	95.8
Granulated nitroglycerin powder, 5%	5	c35	60	..	..	..	..	.. ..	67.6	21.6	53.3
Black blasting powder	..	...	73	..	..	..	..	11 16	71.6	6.8	58.6

a Wood pulp, flour and sulphur.
b Wood pulp only.
c Sulphur, coal and resin.

*Eng. and Min. Journal.

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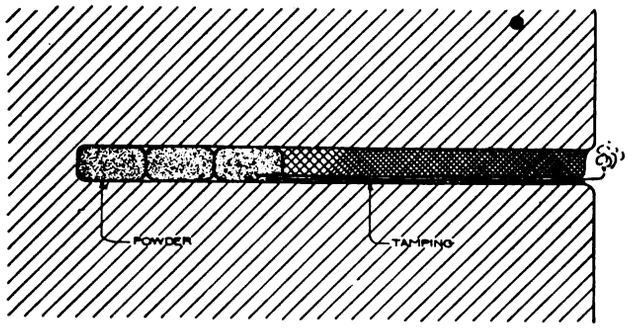

Fig. 10—Drill Hole, Showing Squib Lighted.

The squib has the advantage of cheapness, and usually of time saving, but is uncertain on account of possible caving of the needle hole. Another objection is the danger of igniting explosive gases that may be present.

To make the passage for the squib more substantial, a blasting barrel, Fig. 11, is sometimes

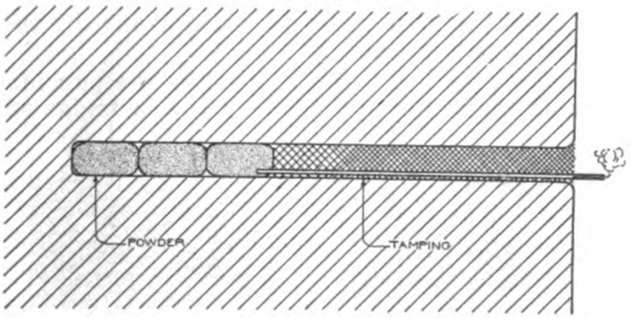

Fig. 11—Drill Hole, Showing Blasting Barrel in Place.

used, which is a section of pipe of suitable length and diameter. The squib is used in the same manner as when the passage is formed by a needle. The blasting barrel is usually recovered after an explosion and used again.

A second means of igniting a charge of powder is fuse, generally called safety fuse, Fig. 12, which

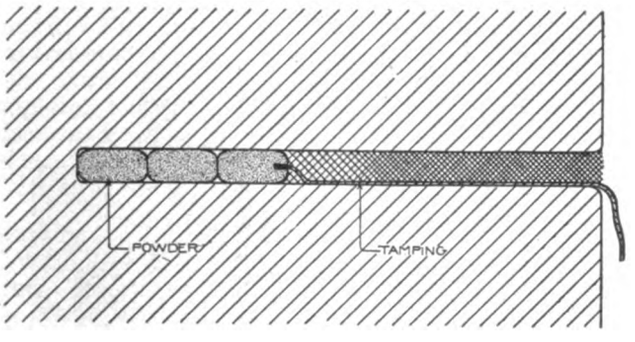

Fig. 12—Drill Hole, Showing Fuse in Place.

is a train of fine powder enclosed in hemp or cotton, covered with one or more layers of tape for the purpose of waterproofing. When lighted at one end, flame travels along inside the tube to the other end, where, if placed within the charge, it ignites the powder. Fuse usually burns at the rate of 1½ to 2 feet per minute, and the rate is specified by the manufacturer. The blaster is thus enabled to estimate the length of fuse required to enable him to reach a safe place, and by cutting a fuse to proper length, may take more time than a squib would allow. The rate of burning cannot be guaranteed, however, as fuse may be subjected to injury that would interrupt the train of powder. It is advisable to make tests of the fuse in use for rate of burning. Failure of a charge to explode may be only temporary, and the flame may be started again on its path after an interval. Many lives have been lost by returning prematurely to investigate a delayed ignition. Fuse is prepared for conditions varying from dry to submarine, the difference being mainly in the character of taping. The uncertainty of fuse and its tendency to flame are serious objections.

A third method of ignition involves the use of detonators. It may be applied to low explosives, but is most used in firing high explosives and permissibles, and is the only approved method of firing the latter. A detonator is distinguished from an electric detonator. The former is commonly called a blasting cap. A blasting cap (or detonator proper), as shown in Fig. 13, is a copper cylinder

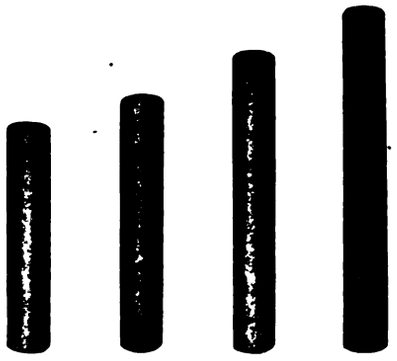

Fig. 13—Detonators.

about a quarter of an inch in diameter and from 1¼ inches to 1⅞ inches long, filled for about one-third to one-half its length with mercury fulminate or a mixture of mercury fulminate with potassium chlorate. The sensitiveness and other qualities of these substances have already been described. The

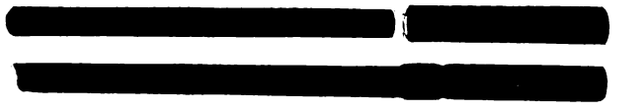

Fig. 14—Fuse and Detonator.

other end of the detonator is left open for inserting the end of a fuse, which, when lighted, conveys flame directly to the mercury fulminate or other composition. The ignition of this substance produces a shock that is ample to detonate completely the charge of high or permissible explosive. In the attachment of fuse to blasting cap, Fig. 14, it is desirable to have a tight fit, in order to maintain their relative position, but not so tight as to break the powder train inside the fuse. The best and safest means of attaching is a crimper designed for the purpose. The crimper is often combined with a fuse cutter in one tool.

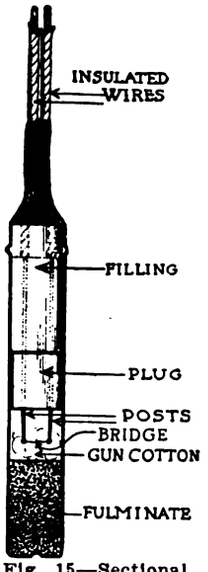

Fig. 15—Sectional View of Electric Detonator.

An electric detonator, or electric blasting cap, serves the same purpose as the detonator or blasting cap used with fuse, but is so constructed that it can be fired by discharging an elec-

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tric current through it. It consists, as shown in Fig. 15, of a copper shell, containing at its inner end the charge of mercury fulminate, followed sometimes by guncotton, next a waterproof plug and at the outer end a quantity of filling material. Insulated copper wires enter the cap and traverse the filling material and plug, terminating in the fulminate or guncotton. The ends, or posts, of the copper wires are connected by a platinum bridge, which is heated to incandescence by the electric current, thus exploding the charge. Detonators, whether electric or not, are designated by numbers, each number representing a different strength. No. 6, for example, contains 1.00 gram of the charge.

Fig. 17 Primer with Electric Detonator.

An electric squib, Fig. 16, has been designed to replace the ordinary type of squib when blasting powder is used. It is a paper shell, containing a composition that flames when the electric current passes through it, and thus ignites the blasting powder. It is instantaneous, avoids the fumes that would come from an ordinary squib and is safer.

Electric Squib (Actual Size) Fig. 16.

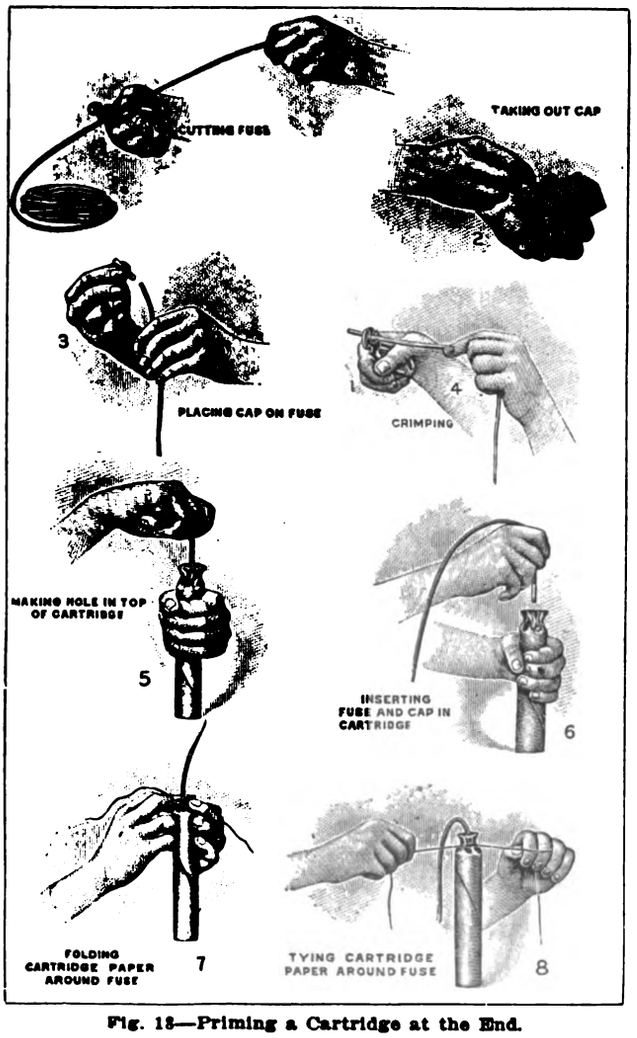

Fig. 18—Priming a Cartridge at the End.

If it is desired to fire several shots in succession, detonators may be used that are provided with different lengths of a slow burning composition and are all connected in one electrical circuit. Thus, the order of shots and the time between any two consecutive shots may be arranged at will, only one electrical impulse being required for ignition of all. The method is not in general use, however, in coal mining.

Primer

In the use of high or permissible explosives, only one of the cartridges, usually the outer one of a charge, is in direct contact with a detonator. This cartridge is known as the primer, Fig. 17. The preparation of the primer is shown in Fig. 18.

After the fuse has been inserted into the end of the detonator and the latter crimped on the fuse, the cartridge wrapper is unfolded at one end and a hole is punched in the end of the cartridge by means of a wooden stick. The detonator is imbedded in the explosive material as far as the crimping. Then the loose paper is folded about the fuse and tied with a string.

Another method, Fig. 19, involves the punching of a hole diagonally in the side of the cartridge and

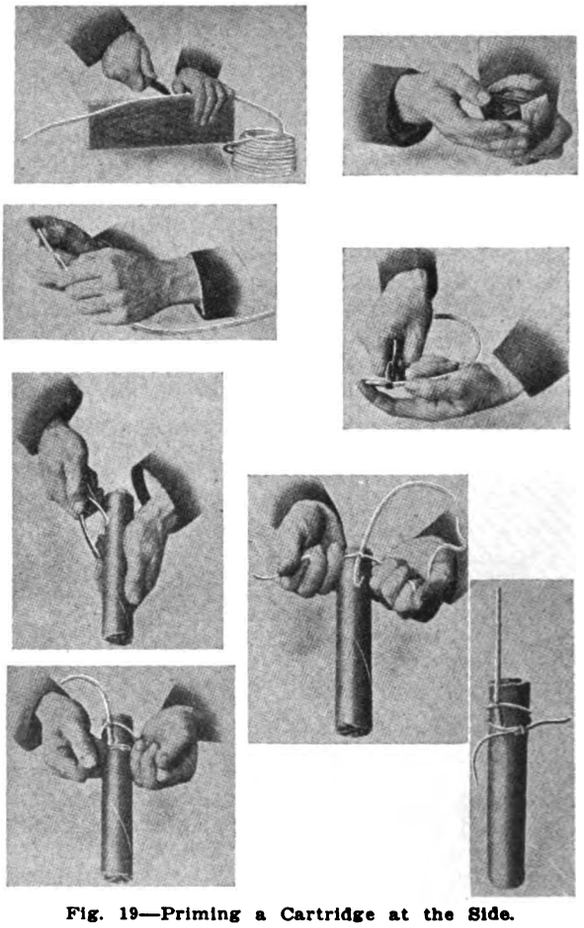

Fig. 19—Priming a Cartridge at the Side.

inserting in it the detonator, binding the fuse to the outer surface of the cartridge with a string. This method is not so generally accepted, because of the liability of damage to the fuse through abrasion or bending, also because the greatest shock from a detonator is in line with its axis and away from the fuse or wires. The method of passing fuse entirely through a cartridge is a danger-

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ous one, since bends or breaks may thus occur in the fuse, and the explosive may be burned, instead of detonated.

When electric detonators are used, the primer is prepared similarly, with detonator either in the end or side. Some users recommend the side method for electric detonators, but the practice is by no means universal. A method that has been recommended for making a primer with electric detonator is shown in Fig. 20. The strength of the

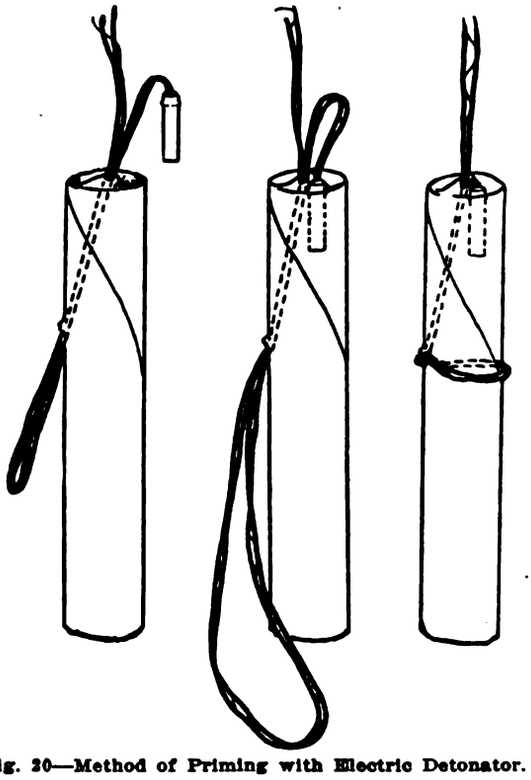

Fig. 20—Method of Priming with Electric Detonator.

detonator should be adapted to the work required. One too strong is better than one not strong enough. The use of No. 6 or stronger detonators is recommended for firing permissible explosives. Tests show that explosions are quicker and more complete, and consequently a smaller volume of poisonous gases is generated when such detonators are used. Also, unfavorable conditions, such as age of the explosive, are less effective.

Tamping

With the primer properly prepared and placed in the hole outside of the other cartridges, damp clay or other incombustible material is tamped in upon the charge and around the fuse or electric wires extending to the mouth of the hole. The first six inches or so of tamping should be comparatively loose, in order to avoid disturbing the charge and detonator, but the remainder should be packed firmly, since the explosive gives better results on the coal when the resistance of the material in the drill hole is greater. A longitudinal section of the hole is shown in Fig. 21.

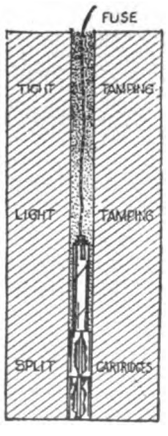

Fig. 21—Section of a Charged Drill Hole.

Electrical Method of Firing

The method of firing shots electrically has many advantages. First of all, it is safer. The charge can only be ignited by the person who controls the electric current, and he does not incur the risk so common with fuse or squib of ignition before he has reached a safe place. Delayed ignition is practically unknown when electricity is used. The danger of igniting gas or dust from squib or fuse flame is absent. Fumes of burning fuse are eliminated. Several shots may be fired simultaneously, thereby increasing the effect over that from firing the same shots separately. Electrical detonation of the eplosive is found to be more complete and efficient.

Electric detonators may be obtained with wires from 4 feet to 20 feet in length. In any case, the wires should be long enough to extend at least a few inches out of the drill holes. At their ends good electrical connection is made to copper leading wires, which in turn are connected to the poles of the blasting machine. Leading wires may be two single wires or one duplex cable. In either case, they are thoroughly insulated. To connect the electric detonators in adjacent holes, when several are to be fired simultaneously, a smaller wire, known as connecting wire, is used, and the detonators are

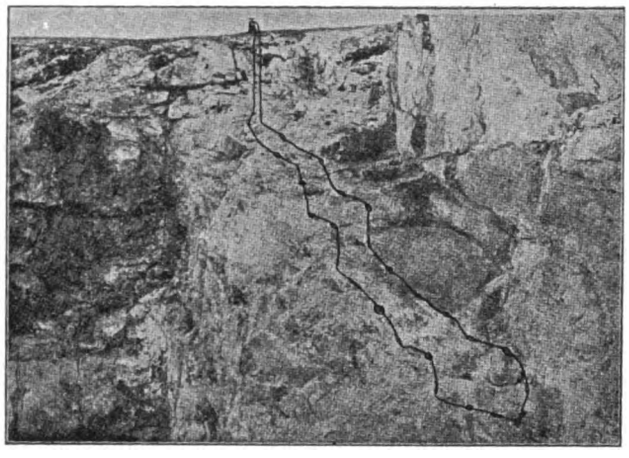

Fig. 22—Blasting Circuit Connected in Series.

connected in series, as shown in Fig. 22. By this arrangement, the firing of all the detonators is assured, if one is fired.

The electric current necessary is usually generated with a blasting machine, often called a battery. The machine is essentially a dynamo, in which the input is the blaster's physical energy and the output is electrical energy. The average size of blasting machine for underground use

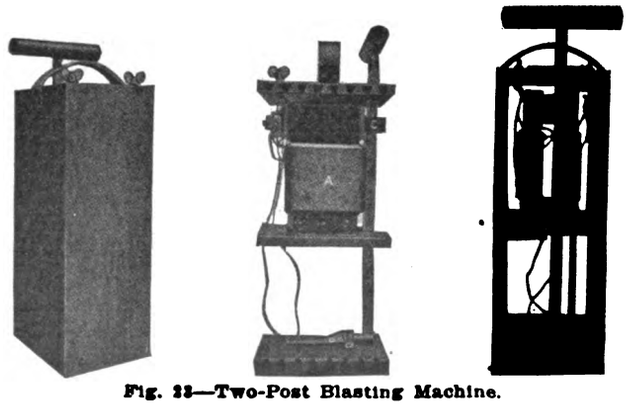

Fig. 23—Two-Post Blasting Machine.

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stands about 15 inches high, weighs 20 to 25 pounds and has a capacity for firing 20 to 30 electric detonators simultaneously. Views of a typical two-post machine are shown in Fig. 23. An armature, B, is set between two electro-magnets, A. A rack bar, the handle of which extends above the top of the box, meshes with a pinion, C, on the revolving armature shaft. When the rack bar is pushed down vigorously, a current is generated by the revolution of the armature between the electro-magnets. The strength of the current accumulates until it reaches a maximum when the lower end of the rack bar is at the bottom. At this stage, the rack bar presses down the contact spring, the circuit through the magnets is broken and the current is discharged through the posts at the top, to which are attached the leading wires.

Both larger and smaller blasting machines are on the market. A small one, designated as a pocket machine, Fig. 24, weighs only 4½ pounds, and has a capacity of three detonators. The smaller size is especially convenient in coal mining because of its easier portability, and its capacity is equal to the ordinary requirements in such mines. Its general principles of construction and operation are the same as those of the larger machines. The handle is not pushed down for firing, as in the other types, but is turned about its axis with a vigorous twist. The fact that the handle is detachable makes the machine somewhat safer from unauthorized use.

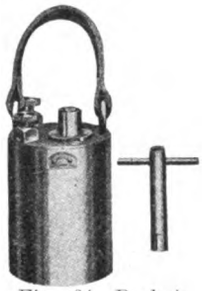

Fig. 24—Pocket Blasting Machine.

When blasting machines are used for firing, there are two tests necessary to make in order that the best results be obtained. One test is for the condition of the circuit, the other for the efficiency of the machine.

The test on the circuit is made with a galvanometer, preferably one of pocket size, designed expressly for this purpose, which consists essentially of a magnetic needle and a dry cell battery, so weak that it incurs no risk of firing a detonator. The resistance of the circuit may be computed, knowing the resistance of the detonators and of the wire used. It may also be taken from tables prepared for the purpose. When the terminals of the system of wiring are connected to the posts of the galvanometer, the needle is deflected through an angle varying inversely as the resistance. Since the scale is graduated to measure the resistance in ohms, the reading may be compared with the computed resistance. Substantial agreement between the two indicates a satisfactory condition of the circuit. A reading lower than the computed value would probably be due to a short circuit, while one above the computed value would be regarded as evidence of a poor connection. By making similar tests on successive portions of the circuit, the faults may be located and remedied.

The test on the blasting machine is made for the purpose of determining its capacity, which may vary with use. If more detonators than the capacity of the machine were put into a circuit for firing simultaneously, some would not fire, or perhaps none would fire. The instrument used for the test is a rheostat, which consists of a number of coils of wire, each with a known resistance, so arranged that any one or more can be connected into an electrical circuit. In making the test, as shown in Fig. 25, coils of the rheostat, R, with resistance equal to that of a certain number of electric detonators are wired into a circuit with a blasting machine and a single detonator. If the machine is now operated in the usual way, the consumption of current is the same as if all the detonators were actually in the circuit. The firing of the single detonator, or the lighting of a lamp in its place would indicate that the machine had a capacity at least equal to the sum of all the resistances. By successive trials with different resistances, the maximum capacity could be found.

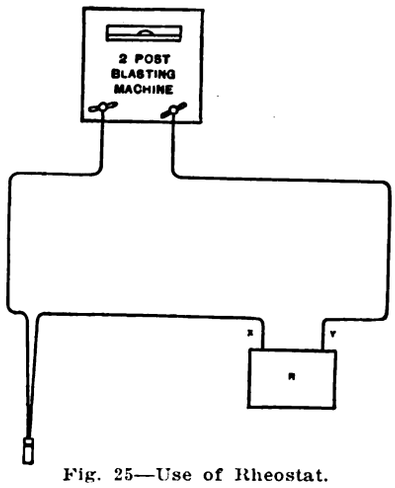

Fig. 25—Use of Rheostat.

Thawing

Since many of the high explosives and many of the permissibles contain nitroglycerin, proper and safe methods of thawing are important. It is essential that the heat be moderate, because with increased temperature the explosive is more sensitive to slight shocks, and may even be fired by high temperature alone. Some crude methods, such as carrying in the clothing, placing near a fire or soaking in hot water may be dismissed as obviously unsafe from a consideration of the properties of nitroglycerin.

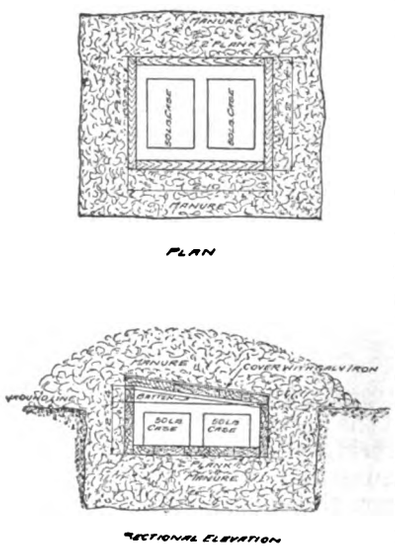

Fig. 26—Thawing Box Surrounded with Manure.

A simple method that is often practical is the placing of the explosive, enclosed in a tight box, under a pile of fresh and warm stable manure, Fig. 26. There is little danger, if any, of overheating, but care must be taken to prevent moisture from reaching the explosive, and the pile must be renewed at intervals, depending on the air temperature

A considerable improvement is the thawing kettle, which has a capacity of 60 pounds of dynamite for the largest size In external appearance, it resembles a tin pail, but is composed of two parts, an outer shell for hot water and a tight inner compartment, surrounded by the hot water and con-

*"Shot Firing in Coal Mines by Electricity Controlled from Outside," Technical Paper 108, Bureau of Mines.
"Shot Firing in Coal Mines by Electric Circuit from the Surface," Transactions American Institute of Mining Engineers, Vol. 50, p. 723.
†"A Setback to Electric Shotfiring," Coal Age, Vol. 2, p. 832.

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taining the explosive. Sometimes insulating material is used to assist in retaining the heat. One type is shown in Fig. 27. It is essential for safety that the heating of the water be completed in another vessel, before the water is placed in the kettle. The temperature should not be greater than can be borne by the hand. A modification of the kettle provides a galvanized iron tube for each cartridge to be thawed, as shown in Fig. 28, instead of placing the cartridges loosely in the inner compartment. By changing the water at intervals, or by protecting against cooling, the explosive may be kept at a temperature suitable for use as long as is generally necessary.

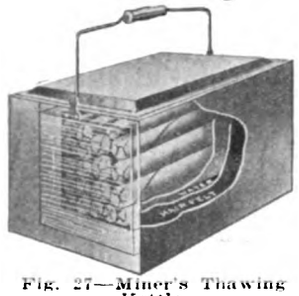

Fig. 27—Miner's Thawing Kettle.

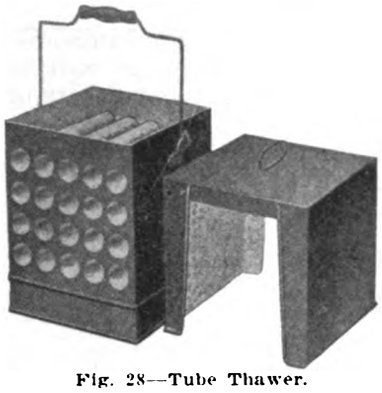

Fig. 28—Tube Thawer.

For thawing large quantities, a thaw house should be erected. An example of such a structure, about 6 feet square and 7 feet high, with capacity of 500 pounds of explosive, is shown in Fig. 29.

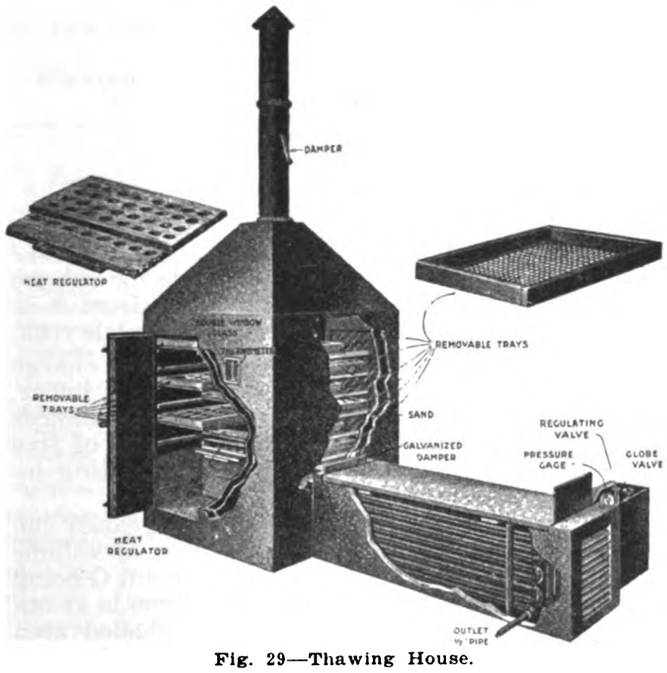

Fig. 29—Thawing House.

Exhaust steam is used for heat, and the steam coils are placed outside the compartment for explosives, in order to keep the temperature within safe limits. Hot water heat is sometimes used.

Storage

It is desirable to use explosives in as fresh a condition as possible, but at most mines the storage of a certain quantity is necessary, and for this purpose, magazines are provided. In no case should the storage space be in the mine. The important requirements are safety from ignition of the explosive and preservation of the explosive in condition for use.

Safety from ignition is attained chiefly by making magazines fireproof and bulletproof, as well as proof against thieves, by locating them at a distance from other buildings and frequented places, by using no metal in the interior of the magazine and by care in handling and piling the packages. Preservation of the explosive is accomplished chiefly by ventilation, protection from the weather and maintaining of proper temperature. In no case should detonators of any type be stored in the same magazine with high explosives, although it is considered safe to store black powder and high or permissible explosives in the same structure, if different parts are assigned for each. A standard type of magazine is shown in Fig. 30.

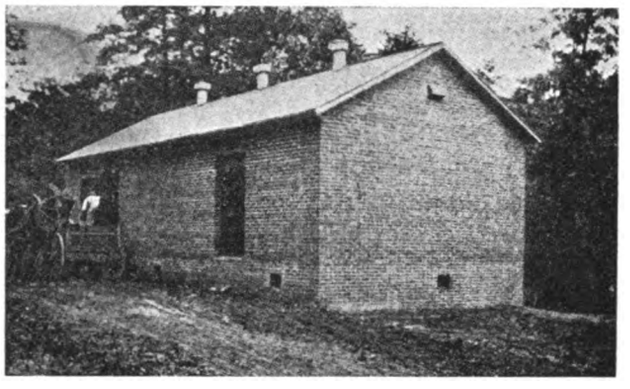

Fig. 30—Magazine.

Brick walls with iron doors are usually considered to make a fireproof structure, although a galvanized covering over wood is effective, particularly when the space between is filled with sand. Fireproof construction should not be depended on entirely, but provision should be made for removal of the contents in case of fire near the magazine. Either of the above is bulletproof on the sides, and roofs are made so with sand packing. The magazine should be solidly built and provided with a secure lock. The proper distance from other buildings depends on the quantity of explosive stored and the character of intervening ground, but laws bearing on this point aim to leave a safe margin. Floors and interior walls are of wood preferably, exposed nails or other iron or steel being avoided. In handling packages of explosives into and out of the magazine, the character of the explosive must be kept in mind; for example, dynamite must be handled so as to avoid dropping the cases, or allowing anything to drop upon the cases. Dynamite is preferably stored so that the cartridges have their long dimension horizontal, to reduce to a minimum the danger of nitroglycerin leakage. Powder kegs should be stored with the axis horizontal, in order to secure ventilation between the kegs. No packages should be opened in or near a magazine.

Ventilation is necessary in order to keep the explosive in normal condition. Too much moisture or too little moisture is likely to change the chemical composition of either class of explosives. Suitable openings in the sides and roof of the building serve the purpose of ventilation. High explosives magazines are heated in cold weather much as thaw houses are heated. In summer, the ventilation serves to reduce the inside temperature.

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Portable steel buildings are sometimes used as magazines. Many of the precautions that should be taken are rendered difficult by this type of construction, but for a temporary magazine they serve their purpose. For storing small quantities close to the work, covered iron wagons or low trucks are sometimes used.

Accidents and Precautions

Fatal accidents due to explosives in the bituminous coal mines of the United States constitute about 5 per cent. to 7.5 per cent. of the total. Classification of accidents from this source is given in the following table:*

	Per Cent.
Handling and transportation	16.79
Handling caps, detonators, squibs and fuse	1.20
Thawing explosives	.73
Tamping	2.97
Premature blast and short fuse	24.87
Blown-out or windy shot	5.47
Flying pieces of rock or coal	16.71
Returned too soon	7.97
Delayed blast	.90
Shot breaking through pillar or rib	5.88
Suffocation by powder gas	3.45
Striking unexploded charge in removing debris	.08
Drilling into unexploded charge	1.88
Unclassified	11.10
	100.00

It is significant that a decrease in accidents accompanies an increase in the quantity of permissibles used.

Many of the precautions necessary or advisable in the transportation, handling and use of explosives have been mentioned in the pages preceding, and will not be repeated here.

Transportation on the common carriers is controlled by the regulations of the Interstate Commerce Commission and the rules of the American Railway Association. State and local laws govern the transportation elsewhere on surface and underground.

The mining laws of the several states treat in more or less detail the handling and use of the explosives adapted to mining, and are valuable summaries of safe practice in the fields covered by them.

All manufacturers of explosives are interested in having their products used safely, as well as successfully, and to this end have prepared lists of precautions for the guidance of their patrons. In addition, the Institute of Makers of Explosives has published a set of rules that should be observed faithfully in the interest of safety.

If proper precautions are taken, such as would be dictated by ordinary prudence and suggested by the codes of rules named above, the handling of explosives is comparatively safe.

*"Coal Mine Fatalities in the United States," Bureau of Mines.

NOTE—We are indebted to the following manufacturers for cuts and illustrations appearing in this article:
Aetna Explosives Co., Inc.
Atlas Powder Co.,
Davis Instrument Mfg. Co.
E. I. du Pont de Nemours & Company,
Hercules Powder Co.

THEORY OF BLASTING*

Conditions Influencing Results of Blasting

Size and number of free faces; cohesive strength of the rock; structure of rock (massive, jointed, laminated, stratified, or fissured); strength and nature of the explosive; character of fuse and tamping; whether the shot acts alone or simultaneously with others; whether the broken rock falls or must be lifted by the blast; form and size of chamber containing the explosive; proportion of length of least resistance to length of the hole, and to height of free faces.

Rules for Blasting

According to the crater theory, a charge in a mass of earth or rock with horizontal surface will blow out a funnel-shaped hole, the sides of which have a slope of 1 to 1 to the free face (Fig. 5). Distance DB is the Line of Least Resistance L; hence the volume of the crater is $V = 0.33\ L \times 3.1416\ L^2 = L^3$ (nearly). Hence general formula for volume of rock loosened is $V = mL^3$. The figure from $m = 0.4$ for tough soft rock, and 0.9 for hard brittle rock.

If the hole is normal, as in Fig. 5, the charge may blow out tamping and fail to break; hence, hole should be inclined (Fig. 6), to reduce chances of a blow-out, as well as to increase the area of free face and volume of the rock broken. Limiting inclination of drill hole is 45°.

The greater the area of free face, the easier can rock be blasted. Fig. 7 shows the area of volume broken when there are two free faces (point G being uncertain) Fig. 8 shows area when charge is at unequal distances from the two faces; shaded area will probably not be removed by the direct force of the blast, but may be broken indirectly. When two or more free faces are exposed, the longest line of

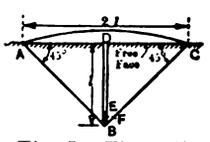

Fig. 5. Theoretical Crater, Normal Hole.

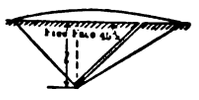

Fig. 6. Theoretical Crater, Oblique Hole.

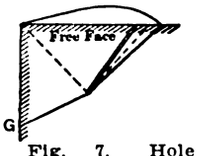

Fig. 7. Hole With Two Free Faces.

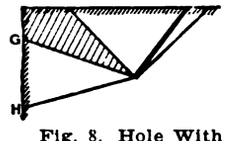

Fig. 8. Hole With Two Free Faces.

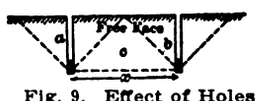

Fig. 9. Effect of Holes Fired Simultaneously.

*Peele's Mining Engineers' Hand Book.

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resistance should not exceed 1.5 L. To obtain the aid of gravity, L should be horizontal, and the longest line of resistance vertical.

L should be proportioned to size and diameter of hole. Table shown below gives the relations of the different dimensions.

RELATIONS OF DIAMETER AND DEPTH OF HOLE AND LENGTH OF LINE OF LEAST RESISTANCE

Diam. of Hole, In.	Depth of Hole, Ft.	L, Ft.	Diam. of Hole, In.	Depth of Hole, Ft.	L, Ft.
1.25	3.50	3.50	1.5	12.00	6.00
1.25	5.75	3.75	1.75	5.00	5.00
1.25	10.00	5.00	1.75	9.00	6.00
1.5	4.00	4.00	1.75	14.00	7.00
1.5	7.50	5.00	....	.....	....

Fig. 9 shows the effect of blasting two holes simultaneously. If a and b are blasted separately, c would not break out; when blasted together c is broken if x is not too great. In average rock, x = 1.5L to 2L; in weak rock, x should be about equal to L.

Rock Coefficient

For three free faces, use 0.66 P; for 4 faces, 0.5 P; for 5, 0.4 P; for 6, 0.25 P.

Size of Drill Hole for Charge

If P = weight of explosive, lb; g = sp. gr. of explosive, and d = diameter of hole, ft.; then $P = 0.34\ gd^3$.

In general, experience and judgment are more useful in determining proper methods than the theories and rules above summarized.

SPACING OF HOLES, CHARGES AND RESULTS OF MACHINE-DRILL BLASTS*

Rock	Kind of work	Aver depth of hole, ft	Aver dist of rows from face, ft	Aver dist apart of holes, ft	Ft of hole per cu yd	Grade of explosive, % Ngl	Kind of explosive	Explosive per cu yd of rock, lb	Diam of hole, in
Limestone..	Canal.	12	8	8	0.40	40	A	0.75	.....
Limestone...	Crushed stone	6	5	6	1.00	40	A	0.70	.....
Limestone .	Cement.....	20	.....	.....	....	50	A	0.37	.....
H'd dolomite	R R thro'-cut (a)	20	7	7	0.42	60	A (b)	1.05	4.5
Limestone...	.. ..	15	.....	.....	0.43	50	A	0.26 (c)	.....
Limestone ...	Canal.	14	4	6	....	40	A	0.38	.....
						60	A	0.38	.....
Limestone....	Canal (d).....	13	8	6	0.56	40	A	0.38	.....
						60	A	0.44	4.5
Hard limestone	Crushed stone	26 (e)	9	6 5	0.47	60	A	1.35	5.5
		12 (f)	.....	6		60	A		4.5
Sandstone....	R R side-cut	20	12-18	12-18	0.10	40	B	1.00	.....
							A	0.10	.....
Sandstone...	R R thro'-cut	20	12-18	12-18	0.20	40	B	2.00	.....
							A	0.20	.....
Sandstone....	R R cut.....	20	18	14	0.15	....	B	0.15 (g)	.....
Soft shale....	R R side-cut..	24	12-18	12-18	0.08	40	B	0.70	.....
							A (c)	0.03	.....
Hard shale...	R R thro'-cut.	24	12-18	12-18	0.20	40	B	1.50	.....
							A (c)	0.10	.....
Granite.....	Rubble.....	16	5	5	1.36	60	A	0.20	.....
Hard granite.	Crushed, rubble	(h)	.....	5	....	75	A	.....	2.5
						60	A		
Gneiss.....	.....	12	.....	.....	1.33	40	A	0.60	.....
Gneiss.....	.....	14	.....	.....	0.63	40	A	0.50	.....
Syenite.....	Mine.....	12	2.5	6 (i)	1.70	40	A	0.67	.....
Iron ore.....	Mine.....	12.5	.....	.....	0.32	52	A	0.44	.....
Seamy trap..	Crushed.....	14	.....	.....	0.35	75	A	0.20	.....
Massive trap.	.....	16	.....	.....	1.00	40	A	0.70	.....
Seamy slate..	R R thro'-cut.	12 (j)	10	10	0.27	60	A	1.11	4.5
Seamy rock..	Dam filling...	18	.....	.....	0.13	....	B	1.85	.....

A. Dynamite. B. Black Powder. (a) 35 holes. (b) Holes sprung with 2 lb. dynamite. (c) Holes sprung. (d) 45 holes. (e) 60 holes; top holes ,vertical, 26 ft. deep. (f) 75 holes; 2 toe holes, one at 15° and one at 60° with vertical, 10 to 14 ft. deep, the former being 6 ft. away from and 2.5 ft. in front of latter. (g) Sprung 3 times. (h) First row 6 to 15 ft. from face; second row, 7 to 10 ft. from first row; about 2.5 lb. of 75% dynamite and 6.25 lb. of 60% per hole. (i) Holes staggered. (j) 30 holes; holes at angle of 15° with vertical. Sprung with 3 lb. of dynamite.

SPACING OF HOLES, CHARGES AND RESULTS OF CHURN-DRILL BLASTS*

Kind of rock	Character of work	No of holes	Diam of hole, in	Aver depth, ft	Aver dist holes from face, ft	Aver dist apart of holes, ft	Total explosive used, lb	Grade of explosive, %	Kind of explosive	Rock blasted, cu yd	Explosive per cu yd, lb
E(a)	Crushed stone	4	5⅝	66	....	....	5 500	.....	A	20 000	0.275
E	Crushed stone	8	5	50	12	12	1 200	40	A	.....	.....
E	Cement q'rry	.....	5	36	10	14	60(b)	40	A	.....	.....
E	Cement q'rry	8	6	65	20	20	4 000	40	A	.....	.....
E	Open-pit iron mine	...	6	20	15	15	65(b)	40	A	.....	.....
E	R R ballast..	8	6	48	19	18	3 300	40	A	5 720	0.578
E	Cement q'rry	9	6	62	32	20	1 800	40	A	12 320	0.349
							2 500	60			
E	Cement q'rry	7	6	60	23	15	500	60	A	6 610	0.514
							2 900	40			
E	Hard R R ballast	8	6	95	33	28	2 200	.....	B	27 300	0.249
							3 350	60	A		
							1 250	40	A		
E	Lime quarry	3	6	100	24	17	1 200	60	A	5 720	0.315
							600	40			
E	Cement q'rry	9	6	52.5	36	20	1 720	60	A	13 660	0.309
							2 500	40			
F(d)	Crushed sand	4	4	40	13	13	275	.....	A	1 387	0.199
G	Copper mine.	1	.....	80	.....	.....	4 000(e)	40	A	12 000	0.333
H	R R thro'-cut	578	4	25-40	(f)	(f)	1 200	60	C	35 000	0.814
							27 275	35			
I J	Open-pit mine	.....	5⅝	60	40	35	100(g)	40	A	3 100	0.323
			5⅜	60	15	15	625	.....	D	500	1.250
K	Placer dredge	.....	.....	.30	20	50	30(i)	.80	A	.....	.....
.....	R R thro'-cut	8	4.5	32-37	(h)	22	50 300	2F-3F	D	16 113	0.311
L	Copper mine.	12	.....	65-125	.....	100	58 050	.....	(j)	200 000	0.290

A. Dynamite. B. Gelatin. C. Gelatin dynamite. D. Black blasting powder. E. Limestone. F. Sandstone. G. Porphyry. H. Basalt. I. Copper porphyry. J. Tough carbonate. K. Gravel. L. Ore and capping. (a) Average ft. per hr., 40. (b) Per hole. (d) Holes sprung with dualite. (e) Sprung with 150 lb. of 40% dynamite. (f) Holes in 5 parallel lines: 1 center line, 2 lines 10 ft. away; 2 lines 24 ft. from the center line. Holes staggered, 14 ft. apart, and chambered with 60% dynamite. Loading required 8 days. (h) Holes on center line, the first being 18 ft. from the face. Holes sprung with 15 sticks 60% dynamite, then 55 sticks, then 275 sticks. Tamping, after springing, cost $12 to drill out. (i) Per hole. (j) Mostly dynamite

CHARGES FOR BOULDER BLASTING*

Weight of Boulder, Lbs.	Approx. No. of 1.25x8-in. cartridges (40-60% dyn.			Weight of Boulder, Lbs.	Approx. No. of 1.25x8-in. cartridges (40-60% dyn.		
	Mud-Capping	Snake-Holing	Block-Holing		Mud-Capping	Snake-Holing	Block-Holing
500	1.5	1	0.25	4000	4	3.5	1.25
1000	2	1.5	0.5	5000	4.5	4	1.75
2000	3	2.5	0.67	7500	6	5	2.5
3000	3.5	3	1	10000	8	6	3.5

CHARGES USED IN CHAMBER AND COYOTE BLASTS*

Case	Rock	Rock loosened, cu yd	Dynamite, lb	Black powder, lb	Judson powder, lb	Lb per cu yd		
						Dynamite	Black powder	Judson powder
I.....	Granite....	110 000	144	35 000	.....	0.001	0.320	.....
II.....	Porphyry ..	50 000	100	.....	1 200	0.002	.....	0.024
III....	Granite....	80 000	5 400	29 050(a)	.....	0.067	0.374 (a)	.....
IV.....	Limestone..	.....	....	12 000	.....	....	.....	.....
V.....	Sandstone .	220 000	1 250	43 100	.....	0.006	0.195	.....
VI.....	Rock.....	350 000	11 400	.....	114 000(b)	0.033	.....	0.326
VII....	Basalt.....	14 280	....	.....	3 500	....	.....	0.245 (b)
VIII.	Black trachyte	250 000	3 000	.....	30 000	0.012	.....	0.120
IX.....	Limestone..	1 700	26	2 775	.....	0.015	1.632	.....
X.....	Trap.....	150 000	7 000	.....	.....	0.047	.....	.....
XI.....	Granite....	440 000	32	18 250	.....	0.0001	0.042	.....
XII....	Gravel.....	.....	....	17 500	.....	....	.....	.....
XIII...	Gravel.....	150 000	....	50 000	.....	....	0.333	.....
XIV.	Cemented gravel	500 000	....	.....	36 400	....	.....	0.072
XV....	Gravel.....	200 000	3 500	.....	.....	0.018	.....	.....
XVI...	Rock.....	10 000	500	7 500	.....	0.050	0.750	.....
XVII...	Basalt.....	40 000	....	35 000	.....	....	0.875	.....
XVIII.	Basalt.....	90 000	....	34 625	.....	....	0.385	.....
XIX...	Basalt.....	40 600	....	.....	10 000	....	.....	0.247
XX....	Basalt.....	110 000	....	.....	21 000	....	.....	0.191
XXI...	Basalt.....	56 900	....	.....	10 000	....	.....	0.179
XXII..	Hard basalt	400 000	20 000	431 000	.....	0.050	1.078	.....
XXIII.	Basalt.....	54 800	....	.....	8 000(b)	....	.....	0.146 (b)
XXIV	Cemented gravel	180 000	....	30 025	.....	....	0.167	.....

(a) Champion powder, 7 and 9% Ngl. (b) Trojan powder.

*Peele's Mining Engineers' Handbook.

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I. West Beaver Creek dam, Colo. Tunnel 75 ft. below apex of rock, 135 ft. long, with several bends. Cross drifts, 35 ft. long, each way from end of tunnel. Charges at ends of cross drifts, with 3000 lb. of powder along outer wall or remainder of cross drift. Tamping: rock, earth and timbers.

II. Otay, Cal. Tunnel, 4 by 5.5 ft., 50 ft. long. 18-ft. Y-branches at ends for chambers. Charges: 4000 lb. Judson powder and 50 lb. dynamite in one chamber; 8000 lb. powder and 50 lb. dynamite in other. Cost, 5c per cu. yd.

III. Morena dam, San Diego, Cal. Open cut perpendicular to face, with 4 by 5-ft. drift, 115 ft. long, parallel to and 100 ft. from cut. Chambers sunk beneath floor at end and 70 ft. from face. Face chambers contained 500 lb. 7% Champion powder and 1500 lb. 40% dynamite; end chamber, 28550 lb. 7 and 9% powder, 1900 lb. 40%, and 2000 lb. 60% dynamite. Tamping: earth and timber. Cost, 5.05c.

IV. Northampton, Pa. Quarry. Face, 135 ft. high. Drift, 3 ft. wide, and 238 ft. long, along a fault 50 to 100 ft. from face. Four chambers below tunnel, 45 ft. apart, and 3 crosscuts each way, 25 to 56 ft. long.

V. Ferrino, Wash. Quarry. 65-ft. face. Two 3.5 by 4-ft. drifts, 200 ft. apart; one 150 ft. long, with crosscuts 50 ft. apart; each 80 to 100 ft. long. 60% dynamite. Tamping; muck, timber and cement bulk-heads.

VI. Piedra, Cal. Quarry. Average height of face, 91 ft.; average overburden, 68 ft. 6 drifts, each 80 ft. long, with two crosscuts each side. Crosscuts, 40 ft. apart, 40 ft. long. Pits at ends of cuts 60% dynamite and Judson R.R.P. Cost of explosives, 2.6c per cu. yd.

VII. St. Helena, Ore. Quarry. Drift, 3 ft. wide by 46 ft. long, with crosscuts at end, one 32 ft. the other 40 ft. long. Halfway from face, a crosscut in each side 32 ft. long. No. 2 Trojan powder in 4 charges of 150 to 250 lb. in short cut and 5 charges of 400 to 700 lb. in long cut.

VIII. Corona, Cal. Quarry. Overburden, 80 ft. Drift, 110 ft. long, with side drift 60 ft. from face, 15 ft. long to left and 40 ft. to right; diagonal drift 80 ft. from face, 40 ft. to left, and at the end a diagonal drift 50 ft. to the left and a straight drift 50 ft. long to right. End of drifts charged with Judson R.R. powder and 60% dynamite.

IX. U.P.R.R. 18-ft. cut. 2 pits charged with 26 lb. dynamite and 2775 lb. powder.

X. Hudson River. 200-ft. face. 1 drift at bottom, 65 ft. deep; other drift, 60 ft. from top of face, 80 ft. deep. Two 25-ft. shafts at top; also drill holes.

XI. Long Cove, Me. Shaft 4 ft., 64 ft. deep, with two drifts at bottom, each 27 ft. long. Cross cuts from end of drifts, 26 ft. long. Explosives in the crosscuts.

XII. Paragon hydraulic mine. Face, 150 ft. high. Drift, 110 ft. long. Crosscut at right 70 ft. long, with drift at end, parallel to main drift, 55 ft. long. Crosscut at left, 60 ft. long, with drift at end, 30 ft. long. Much space left untamped for expansion of gases.

XIII. Blue Point hydraulic mine. Drift, 3 by 4 ft., 275 ft. long. 6 crosscuts, each 120 ft. long on left. 6 on right, each 80 ft. long. First drift on right, 75 ft. from portal, and at end a 15-ft. drift, parallel to main drift.

XIV. Dardanelles mine. Face 175 ft. high, 1200 ft. long 5 parallel drifts, across each of which were 2 or more crosscuts. Total length of drifts, 1200 ft.

XV. Hydraulic mine. Giant powder No. 2.

XVI. Colorado Dam. Coyote or one-man tunnel, 40 ft. long. 2 crosscuts from end, each 12 ft. long, with pits at end. Explosive, FFB powder and 40% dynamite charged in pits. Tamping: earth. Total cost, 16.9c per cu. yd.

XVII. Oregon R. R. Coyote hole, 2.5 by 3 ft. in hillside, 50 ft. deep. Crosscuts at end, 75 and 45 ft. Charges in the 2 openings.

XVIII. Crooks Landing, R. R. 4 or 5 coyote holes, 80 ft. long, with Ts 40 to 60 ft. long at ends.

XIX. Oregon. R. R. 165 ft. breast.

XX and XXI. Oregon. R. R.

XXII. Snake River, Wash. R. R. 75 coyote holes, 2.5 by 3 ft., each averaging 89 ft. long, run into and then parallel to side-hill face. 3500 ft. of cliff mined by 6177 ft. of coyote holes. 20000 lb. dynamite used in preparing for main blast of F to 5F black powder.

XXIII. Oregon. Coyote holes. No. 2 Trojan powder.

XXIV. Smartsville, Cal. Hydraulic mine. Shaft, 74 ft. deep, with main drift 185 ft. long from bottom. 3 crosscuts, 70, 120 and 170 ft. from shaft, 40 ft. long. On other side 10 lifter drifts from crosscuts, each 15 ft. long, parallel to main drift. Total drifts, 570 ft. long by 2.5 ft. wide by 3.5 ft. high. Material moved, 270 by 180 by 100 ft.

DIMENSIONS OF MAGAZINES—WITHOUT AISLES

Capacity, Pounds	Dimensions, Feet	Capacity, Pounds	Dimensions, Feet
5000	8 x 8	25000	12 x 12
10000	8 x 10	30000	12 x 14
15000	8 x 12	40000	14 x 16
20000	10 x 12	50000	14 x 18

DIMENSIONS OF MAGAZINES—WITH AISLES

Capacity, Pounds	Dimensions, Feet	Capacity, Pounds	Dimensions, Feet
5000	8 x 9	25000	12 x 18
10000	10 x 12	30000	12 x 20
15000	10 x 12	40000	14 x 22
20000	12 x 16	50000	14 x 24

Hercules Powder Company.

DISTANCES FOR MAGAZINES, AMERICAN PRACTICE

Quantity Explosive Stored, Lbs.	Minimum Distance, Ft.			Quantity Explosive Stored, Lbs.	Minimum Distance, Ft.		
	Inhabited Building Screened*	Public Railway Screened	Public Highway Screened		Inhabited Building; Screened*	Public Railway Screened	Public Highway Screened
50	120	70	35	9000	870	520	260
100	180	110	55	10000	890	535	270
200	260	155	75	20000	1055	635	320
300	320	190	95	30000	1205	725	360
400	360	215	110	40000	1340	805	400
500	400	240	120	50000	1460	875	440
600	430	260	130	60000	1565	940	470
700	460	275	140	70000	1655	995	500
800	490	295	150	80000	1730	1040	520
900	510	305	155	90000	1790	1075	540
1000	530	320	160	100000	1835	1100	550
1500	600	360	180	150000	1965	1180	590
2000	650	390	195	200000	2095	1260	630
3000	710	425	215	250000	2215	1320	660
4000	750	450	225	300000	2335	1400	700
5000	780	470	235	350000	2445	1470	735
6000	805	485	245	400000	2555	1530	765
7000	830	500	250	450000	2655	1590	795
8000	850	510	255	500000	2755	1650	825

*"Screened" as here used signifies that the building containing explosives is screened from buildings, railways, etc., by either natural or artificial barriers. Where such barriers do not exist, distances should be doubled.

Bulletin 75, U. S. Bureau of Mines.

INGREDIENTS OF HIGH EXPLOSIVES

INGREDIENT	CHEMICAL SYMBOL	FUNCTION	REMARKS
Nitroglycerin	$C_3H_5(NO_3)_3$	Explosive base	Liquid, highly explosive
Nitrocellulose (guncotton)	$(C_6H_7(NO_3)_3O_2)_x$	Explosive base and gelatinizing agent	Solid, highly inflammable, and explosive when dry
Nitrostarch	$(C_6H_7(NO_3)_3O_2)_x$	Explosive base	White powder, highly inflammable and explosive when dry
Organic nitro-compounds	.....	Explosive base, but used primarily to reduce freezing point	Some solid, others liquid; the higher nitro-compounds explosive, the lower non-explosive in themselves
Ammonium nitrate	NH_4NO_3	Explosive bases and oxygen carriers	Solid, not explosive alone; very soluble in water
Potassium chlorate	$KClO_3$	Explosive bases and oxygen carriers	Soluble in water, highly explosive when mixed with combustible matter
Potassium perchlorate	$KClO_4$	Explosive bases and oxygen carriers	Difficulty soluble in water, highly explosive when mixed with combustible matter
Sodium nitrate	$NaNO_3$	Oxygen carrier	Soluble in water, not explosive alone, deliquescent
Potassium nitrate	KNO_3	Oxygen carrier	Soluble in water, not explosive alone, not deliquescent
Wood pulp	.....	Absorbent and combustible	Best combustible absorbent; in highest grades equal to kieselguhr in absorbent capacity
Wood meal	.....	Absorbent and combustible	Fairly high absorbent capacity
Ground coal	.....	Combustible	.....
Charcoal	.....	Combustible	.....
Flour	.....	Combustible	.....
Sulphur	S	Combustible	.....
Chalk	$CaCO_3$	Antacid	.....
Zinc Oxide	ZnO	Antacid	.....
Kieselguhr	SiO_2	Absorbent	Has no value except as absorbent

Peele's Engineers' Hand Book.

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ATLAS POWDER CO.

WILMINGTON, DELAWARE

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ALLENTOWN, PA.
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PITTSBURG, KANS.
PITTSBURGH, PA.
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WILKES-BARRE, PA.

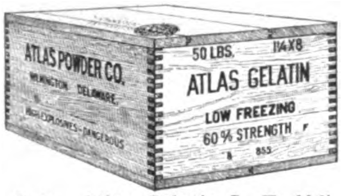
BLASTING EXPLOSIVES

The high quality, uniformity and dependability of Atlas Explosives are recognized by the powder men of all the great metal mines. All grades for every requirement can be furnished conveniently by the nearest one of our many distributing points. Low freezing explosives are furnished on all orders unless the high freezing grades are specified. Nothing weaker than a No. 6 blasting cap should be used to detonate Atlas High Explosives. We now offer a new series of non-freezing powders.

Cartridge—Atlas Powder L. F. 40%

Atlas Non-Freezing—A new explosive that will not freeze. Made in 5 grades, covering all blasting requirements. No headaches. No premature explosions.

Atlas Extra—15% to 60%. Spreads and heaves when exploded. Fumes not objectionable. Not water-proof. Especially recommended for headings, strippings, cuts and underground blasting that is not wet and where a shattering effect is not desired.



Case—Atlas Gelatin L. F. 60%

Atlas Gelatin — 25% to 90%. Practically non-freezing and fumeless. Water-proof. For tunnel driving and rock blasting of all kinds in mines or under water.

Atlas Powder—15% to 75%. Very quick and shattering. Fumes objectionable underground. Partly water-proof. Recommended for outside work in hard rock that must be broken small.

Atlas Permissible—COALITE. Nine grades to meet every coal mining requirement. No objectionable fumes. Moisture and cold resisting. All grades have been tested and approved by the U. S. Government Bureau of Mines.

Atlas Low Freezing R. R. P.—Granular, low grade explosive, invaluable in cuts, strippings or other open excavating that is not wet. Twice as strong as blasting powder. Exploded with dynamite primer. Put up in 12½-lb. paper bags; packed in 50-lb. cases.

Keg—Atlas Blasting Powder

Atlas Blasting Powder—All standard granulations. The smaller the grains, the quicker and more shattering the effect. Little smoke. Hard pressed, dense, regular, moisture resisting grains. Glazed or unglazed. Packed in 25-lb. kegs and 5-lb. cans.

BLASTING SUPPLIES

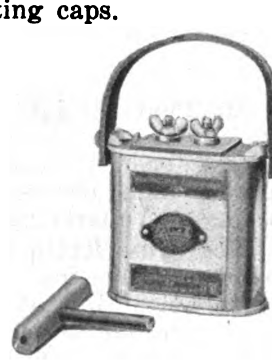
Atlas Blasting Caps—No. 6 and No. 8. Detonated by fuse. Packed 25 or 100 to the tin box, 500 or 5,000 to the case.

Atlas Electric Blasting Cap No. 8

Atlas Electric Blasting Caps—No. 6 and No. 8. Copper or iron wires. Detonated by electric blasting machine. Packed 25 and 50 to the carton—10 cartons to the case. Wires 4 ft. to 30 ft. long. Longer lengths supplied on request.

Atlas Blasting Machines—Six sizes, ranging in weight from 3¼ lbs. to 45 lbs., and in capacity from 5 to 150 electric blasting caps.

Davis No. 1 Blaster—Particularly suited for blasting where not more than 5 shots are fired together. Dimensions: 2″x 4″x2½″. Weight, 3¼ lbs. (net).



Davis No. 1 Blaster

Fuse—Eleven different brands for detonating blasting caps or exploding blasting powder under all conditions. Wrapped in rolls of 100 feet. Packed 10 to 60 rolls to the case.

Atlas Cap Crimpers—No. 4, Cut Throat Crimp; No. 5, Broad Jaw Crimp—for attaching blasting caps to fuse in a safe, secure and reliable way.

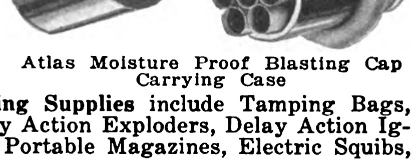
Connecting Wire—Small, insulated copper wire for connecting electric blasting caps to each other. 1-lb. and 2-lb. spools. About 210 ft. to the lb. for No. 20 wire; about 260 ft. to the lb. for No. 21 wire. Sold by the lb.

Leading Wire—Heavily insulated copper wire, used to carry the current from blasting machine to the charge. Single leading wire runs about 52 feet to the lb.; duplex, about 26 feet to the lb. Sold by the lb.

Atlas Galvanometers—For testing electric blasting circuits. This instrument is covered by a leather carrying case, with a sling strap.

Atlas Rheostats—For testing the capacity of blasting machines. Dimensions: ¾″x1¾″x5½″. Weight: 5½ oz.

Atlas Moisture Proof Blasting Cap Carrying Case—The first device of its kind offered the miner that enables him to take proper care of a day's supply of blasting caps. Made of aluminum, ⅞″x2⅛″; holds seven No. 6 or No. 8 blasting caps.



Atlas Moisture Proof Blasting Cap Carrying Case

Other Atlas Blasting Supplies include Tamping Bags, Thawing Kettles, Delay Action Exploders, Delay Action Igniters, Fuse Lighters, Portable Magazines, Electric Squibs, Miners' Squibs, etc.

Other Atlas Products include Chemicals, Nitro Cellulose Solutions, Leather Cloth, Lacquers, Enamels, Pyroxylin Cements.

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E. I. du Pont de Nemours & Company, Inc.

General Offices: WILMINGTON, DEL.

Branch Offices

BIRMINGHAM, ALA.	DENVER, COLO.	KANSAS CITY, MO.	PORTLAND, ORE.	SEATTLE, WASH.
BOSTON, MASS.	DULUTH, MINN.	NEW YORK, N.Y.	SAN FRANCISCO, CAL.	SPOKANE, WASH.
BUFFALO, N. Y.	HUNTINGTON, W. VA.	PITTSBURGH, PA.	SCRANTON, PA.	SPRINGFIELD, ILL.
CHICAGO, ILL.				ST. LOUIS, MO.

Locations of Explosives Plants and Blasting Accessories Factory:

High Explosives: Ashburn, Mo.; Barksdale, Wis.; Du Pont, Wash.; Louviers, Colo.; Ramsay, Mont.; Gibbstown, N. J.
Blasting Powder: Augusta, Colo.; Connable, Ala.; Du Pont, Wash.; Nemours, W. Va.; Fairchance, Pa.; Jermyn, Pa.; Laurel Run, Pa.; Mooar, Iowa; Moosic, Pa.; Oliver Mills, Pa.; Peckville, Pa.; Wapwallopen, Pa.; Wilpin, Minn.
Blasting Accessories: Pompton Lakes, N. J.

High Explosives, Blasting Powder and Blasting Accessories

In the course of more than a century's experience in the manufacture and sale of explosives, the du Pont Company has acquired a very extensive practical knowledge of the qualities needed in explosives for various purposes and the most efficient methods of using them. Du Pont explosives include types for all classes of blasting, all made from carefully selected materials with a care in manufacture which insures the highest quality and uniformity.

The following paragraphs state briefly the chief characteristics of du Pont explosives adapted for metal mining and quarrying, and describe the accessories needed for firing them. For more complete information as to the selection of the proper explosives and the methods of using them to secure the greatest execution at the lowest cost of accessories, time and labor, consult the catalogs and booklets issued by this Company.

EXPLOSIVES FOR MINING

Du Pont Straight 15-60%. This explosive is quick and powerful, resists water well and is recommended for open work where a shattering action is desired. It is low-freezing and is suitable for both mining and quarrying.

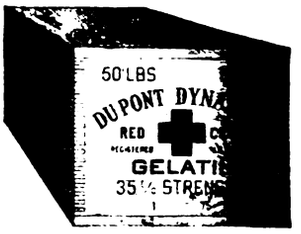
Red Cross Extra 20-60%. This is an all-year-round explosive that works extremely well in mining soft ore. It is also suitable for hard ore where it is not desired to shatter the material. Red Cross Extra is low-freezing.

Red Cross Gelatin 40-90%. A low-freezing explosive that will resist water, such as Red Cross Gelatin, will always find favor among miners. It is plastic and dense and the fumes are comparatively unobjectionable. These qualities make it suitable for close work.

Du Pont Gelatin 25-90%. Where other explosives are inefficient this gelatin does its best work. It is adapted to a wider range of work than any other gelatin dynamite for it has all the virtues of density, plasticity, water resistance, and comparative freedom from obnoxious fumes, and is low-freezing. It is especially adapted for close work of every kind, mining and tunneling in the hardest rock under the most adverse conditions.

Repauno Gelatin 25-90%. This is a dense, plastic, highly water-resisting, and low-freezing explosive which gives a minimum of fumes on explosion. It is particularly suitable for wet work or where ventilation is deficient.

Du Pont Blasting Gelatin 100%. This is the strongest and quickest high explosive manufactured. It can be used in close work as it gives a minimum of fumes when exploded. It is practically waterproof but is not low-freezing. It is especially suitable for blasting hard material in tunnels or in driving shafts.



Packages: Du Pont high explosives cartridges measure from 7/8" by 8" to 2" x 8". They are shipped in cases which contain from 33 to 225 cartridges to the 50-pound case.

Blasting Powder

Blasting Powder is the principal explosive used for blasting where it is necessary to remove the rock or earth covering ore veins. The blasting powder breaks and loosens the ore, earth and rock so that it can readily be loaded with steam shovels. It is not wasted or scattered as would be the case if high explosives were used.

Today the "B" Blasting Powder of the du Pont Company is recognized as the standard by which other blasting powder is rated. The high quality of materials used and their thorough incorporation by means of special machinery give the miner a reliable, efficient explosive. That the miners recognize this is shown by the increasing demand.

"B" Powder is made in seven granulations. This variation in the size of the grains enables the selection of a grain exactly suited to individual requirements. The finer grains are much quicker in their action than the coarser.

Packages: Blasting Powder is packed in 25-pound metal kegs having a moisture proof cap.

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Blast of 17,231 Kegs of Du Pont Blasting Powder and 13,658 Pounds of Du Pont Red Cross Dynamite in 68 Small Tunnels on O. W. & N. R. R. at Ayer, Washington. 300,000 Cubic Yards of Earth and Rock Blasted

EXPLOSIVES FOR QUARRYING

Many of the explosives which are used for ore mining are also suitable for quarry blasting inasmuch as the nature of the work is often similar. There are, however, in addition to the explosives which will meet the requirements of both quarrymen and miners, some explosives which are used only for quarry blasting.

The following list gives the brands of du Pont explosives for quarrying and the properties of each:

Red Cross Extra 20-60%. This explosive will rarely freeze in the coldest weather and is water resisting to a certain extent. It will not shatter the rock when properly loaded.

Red Cross Gelatin 40-90%. This is a moderately slow explosive that is low-freezing and only slightly affected by water.

Dumorite. Dumorite is a guncotton nitroglycerin dynamite which under ordinary conditons will do the work of regular 40% dynamite. As it is a low density powder, running from 135 to 140 cartridges, 1¼"x8", to the 50-pound case, and is loaded on a stick basis against 40% dynamite, it is fully one-third cheaper. Dumorite resists water about as well as Red Cross Extra and is absolutely non-freezing. It will not cause headache.

Du Pont, Repauno and Forcite Gelatin 25-90%. For moderately slow, low-freezing and water resisting explosives these three can be recommended to quarrymen. Du Pont Gelatin is perhaps adapted to a wider range of work than any similar explosive. For quarrying hard rock in wet places any one of the three can be used.

Durox. This is an explosive of relatively high strength yet low density which is especially well adapted for blasting rock where a shattering effect is not desired. It is not low-freezing.

Du Pont Blasting Gelatin 100%. For a quick, shattering explosive this will serve best. It is not low-freezing but is not affected by water.

Du Pont Straight 15-60%. Recommended for open work, in wet, hard material. It is low-freezing.

Du Pont Extra 20-60%. Where it is not desired to shatter the rock in quarry blasting, Du Pont Extra should be used. It is better suited for blasting soft material than straight dynamite but is not low-freezing and does not resist water well.

Du Pont R. R. P. This is the weakest and slowest high explosive—ranking between blasting powder and dynamite. It will rarely freeze in cold weather but even when frozen it will explode properly if the lumps are crumbled.

Blasting Powder

Blasting powders are weaker and slower than high explosives. "A" powder is made in six granulations and "B" in seven. The fine granulations are quicker than the coarser. These blasting powders exert a lifting and heaving, rather than a shattering effect. They cannot be used in wet work although "A" Blasting Powder resists moisture better than "B" Blasting Powder. Neither is affected by cold.

EXPLOSIVES TO MEET VARIOUS QUARRYING CONDITIONS

	DU PONT STRAIGHT	RED CROSS EXTRA	DU PONT EXTRA	GELATIN	DUMORITE	DUROX	BLASTING POWDER	R. R. P.
To shatter and throw hard stone	X			X				
To shatter and throw medium hard stone	Lower strength				X			
To turn out hard, tough stone		X 40 to 60%	40 to 60%					
To turn out medium hard stone		Lower strength	Lower strength		X	X		X
To turn out soft or dimension stone...						X	With air spaces	With air spaces
For wet work.....				X				
In cold weather.....	X	X		Except Blasting Gelatin	X		X	X
To avoid shattering.					X	X	X	X

Packages—All except R.R.P. (in bags) and Blasting Powder (25 lb. keg) are packed in 25 and 50 lb. cases.

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Du Pont Blasting Accessories

Connecting Wire	Electric Blasting Caps	Delay Electric Igniters	Rheostats	Electric Squibs
Leading Wire	Fuse	Galvanometers	Thawing Kettles	Cap Crimpers
Tamping Bags	Blasting Caps	Delay Electric Blasting Caps	Blasting Machines	

With so much money involved in the preparation for blasting, it is readily apparent that it is true economy to buy only the best blasting accessories. The confidence miners and quarrymen have in du Pont Blasting Accessories is manifested by the steadily increasing demand.

In designing the du Pont Accessories, care has been exercised to obtain simplicity of construction and to ensure a positive and effective performance of the machine or device employed. This is particularly true of the du Pont Blasting Machines and testing apparatus. The detonators are composed of the very best materials and the ingredients are selected because of their fitness to accomplish what is required—imparting the necessary shock to the explosive charges to effect complete detonation.

As the largest manufacturer of explosives and because of its extensive experience in the explosives field, the du Pont Company is competent to devise and introduce detonation apparatus especially suited to explosives used in quarrying or ore mining.

If you wish to save time and money, if you desire to get complete detonation of every charge of explosives, insist upon the use of dependable du Pont Blasting Accessories.

Du Pont Blasting Machines—The du Pont Company makes several sizes of Blasting Machines having capacities of 1 to 150 No. 6 Electric Blasting Caps fitted with copper wires. The most popular sizes are the Pocket Blasting Machine and Nos. 3 and 4.

Blasting Machine

The No. 3 Blasting Machine is illustrated to the left. The Pocket Blasting Machine also is shown on this page.

Blasting Machines Nos. 3 and 4 fire 30 to 50 copper wire electric blasting caps. They weigh 25 and 42 pounds, respectively. The machines are compact, as shown in the illustration, easy to operate and portable. The No. 3 Blasting Machine is the standard size for quarry and mine. No. 4 is popular for large quarry blasts.

The Pocket Size fires from one to three electric blasting caps at a time. It has a removable handle to prevent anybody but the shot-firer from firing the charges — a "safety - first" device greatly appreciated by quarrymen and miners. A quick, sharp turn of the handle generates the current which passes through the two terminals seen at the top of the case, and then through leading wires attached to the terminal posts.

Pocket Blasting Machine

Much depends on the blasting machine, and the safest thing to do is to purchase the best.

Thawing Kettle

Thawing Kettles. Every miner and quarryman who works in a cold climate is familiar with the necessity for thawing dynamite. The safest way to do this is to use accessories made particularly for that purpose. Realizing the danger attendant to makeshift thawing of explosives, the du Pont Company has been marketing thawing kettles for some time. These are made with a water-tight compartment for the explosives, which is surrounded by the receptacle for the hot water.

Galvanometers, Rheostats — Practically indispensable accessories in electric blasting in mine or quarry are the galvanometer and the rheostat illustrated on this page. The galvanometer is a small, direct-reading ohmmeter used to detect breaks, short circuits, and points of high resistance in blasting circuits.

Galvanometer

The rheostat is an electric resistance bridge for testing blasting machines.

Electric Detonators. After careful experiments extending over many years, the du Pont Company has developed the No. 6 and No. 8 Electric Blasting Caps as best fitted for

Du Pont No. 8 Electric Blasting Cap—Exact Size

all general work. The selection of the materials and the care in assembling the parts assure a blasting cap that will give complete detonation. These caps are furnished with wires in lengths varying from 4 to 20 feet. The du Pont Company also manufactures Waterproof Electric Blasting Caps, Delay Electric Blasting Caps and Delay Electric Igniters, and furnishes leading wire and connecting wire. The best results are secured from blasting powder by igniting it in the center and for this purpose the Electric Squib is made.

Du Pont electric detonators are packed in cartons of 50.

Cap Crimpers. The du Pont Company furnishes Cap Crimpers of two types, No. 1 and No. 2. The No. 2 Cap Crimper is also used for cutting fuse. One handle in both types of instruments is pointed to serve as a punch for putting holes in cartridges.

Cap Crimper

Safety Fuse. Safety Fuse for use with blasting caps is also sold by the du Pont Company, different types being manufactured for dry, damp or wet work, or work under water. It is made in coils of 50 feet and shipped in wooden cases.

DU PONT EXPLOSIVES SERVICE

For 120 years it has been the constant aim of the du Pont Company to deliver explosives where they are needed—when they are needed. Today this aim has been achieved by a system of mills and magazines, strategically located near practically every great industrial district.

Prompt delivery is but one factor of du Pont Service. We aim to see that our customers use the kind of explosives that will give the best results for their particular work at least expense—and that they are handled, stored and used most efficiently.

In short, du Pont Service is the result of a sincere effort on the part of the du Pont Company to meet and follow the demand, and to pass on to the users of their products, in a practical way, the results of their 120 years of experience and research in the manufacture of explosives.

When you buy from du Pont, you buy more than explosives; you buy du Pont Service.

E. I. DU PONT DE NEMOURS & CO., INC.
Explosives Department
WILMINGTON, DELAWARE

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GENERAL EXPLOSIVES COMPANY

7 South Dearborn Street
CHICAGO

ST. LOUIS, MO. DENVER, COLO. JOPLIN, MO.
BIRMINGHAM, ALA. TAMPA, FLA.

High Explosives
Blasting Powders

Permissible Explosives
Blasting Supplies

HIGH EXPLOSIVES

GENERAL NITROGLYCERIN DYNAMITE is the old reliable "Nitro" powder compounded on scientific principles so as to produce the maximum results. It is very quick and shattering in action and is used for mud capping and for blasting extremely hard rock.

Made in both high and low freezing grades and in strengths ranging from 15% to 60%. A 50-lb. case contains about 100 1¼x8" cartridges.

GENERAL SPECIAL (Ammonia) DYNAMITE is a very economical powder for many kinds of mining work both above and below ground except in wet holes or where extreme shattering is required. It produces but little fumes and can be used wherever moderately good ventilation exists. Made in both high and low freezing grades. Most mines prefer to use the low freezing grade in winter and some use it the year round. Made in strengths from 20% to 60%. A 50-lb. case contains about 100 1¼x8" cartridges.

GENERAL GELATIN is without any question the most satisfactory explosive on the market for underground work. Its plastic consistency, which facilitates loading in uppers, and its freedom from fumes, have made it invariably the favorite wherever used. Long experience in the powder business combined with expert technical knowledge of the requirements has enabled us to accomplish these results.

It withstands water better than any other form of explosive and is made in both high and low freezing grades in strengths from 25% to 90%. A 50-lb. case contains about 85 to 90 1¼x8" or 100 to 105 1⅛x8" cartridges.

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THE GIANT POWDER CO., CON.

SAN FRANCISCO, CALIFORNIA

BRANCH OFFICES
Butte, Montana
Denver, Colorado
Los Angeles, California

BRANCH OFFICES
Portland, Oregon
Salt Lake City, Utah
Seattle, Washington
Spokane, Washington

"Everything for Blasting"

BLASTING EXPLOSIVES

Giant Explosives

Made by the pioneer company in the explosive industry, are still the most popular brand in the West, because their qualities are recognized as superior in meeting every western requirement. When ordering any of the following grades, specify whether low freezing or high freezing explosives are wanted. A new series of non-freezing powders is now offered. Nothing weaker than a No. 6 blasting cap should be used with Giant Explosives.

Giant Non-Freezing

A new explosive furnished in five grades. Cannot freeze. No premature explosions. Does not cause headaches. Any size cartridge furnished.

Giant Powder—15% to 75%

For open work where shattering is demanded.

Giant Extra—15% to 60%

For all rock and ore blasting not exceptionally wet. Fumes not objectionable.

Case—Giant Extra L.F. 60%

Giant Gelatin—25% to 90%

For rock blasting, tunnel driving and all wet work. Waterproof. Practically fumeless.

Giant Coalite

A permissible explosive furnished in nine grades to meet every coal mining requirement. Tested and approved by U. S. Bureau of Mines. Moisture and cold resisting. Unobjectionable fumes.

Giant Judson Improved Powder—5% to 20%

For open excavation blasts that are not wet. A granular, low powder, twice as strong as blasting powder. Put up in 12½ lb. bags; packed in 50 lb. cases.

Keg—Giant Blasting Powder

Giant Blasting Powder

For all dry work where a quick acting explosive is not required. All standard granulations. Glazed or unglazed. Packed in 5 lb. cans and 25 lb. kegs.

Case—Giant Gelatin V.L.F. 40%

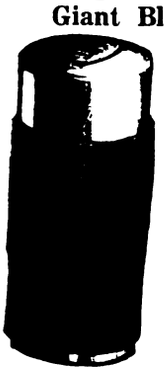
BLASTING SUPPLIES

Giant Blasting Caps—No. 6 and No. 8. For blasting with fuse.

Giant Blasting Cap Carrying Case (Moisture Proof). Carries and protects seven No. 6 or No. 8 blasting caps. The only safe and convenient means for the miner to carry his day's supply of blasting caps.

Giant Electric Blasting Caps—No. 6 and No. 8. Copper or iron wires. For blasting with electric blasting machines.

Giant Blasting Machines—Six sizes, including the Davis No. 1 Blaster, which is small and lightweight and fires five electric blasting caps. Other five sizes have capacity of from 10 to 150 electric blasting caps.



Giant Cap Carrying Case

Fuse—For detonating blasting caps or exploding blasting powder. Eleven brands.

Giant Cap Crimpers—For attaching blasting caps safely and securely to fuse. Two styles: No. 4 and No. 5.

Giant Electric Blasting Cap No. 8

Connecting Wire—For connecting electric blasting caps to each other. Small, insulated copper wire wound on 1 lb. and 2 lb. spools.

Leading Wire—For carrying electric current from blasting machine to charge. Heavily insulated copper wire.

Giant Galvanometers — For testing electric blasting circuits. No. 1 Galvanometer: Dimensions —2"x3"x5½". Weight, 1 lb. No. 2 Galvanometer: Dimensions—1¾"x3½"x4½". Weight 1½ lbs.

Giant Rheostats—For testing capacity of electric blasting machines. Dimensions: ¾"x1¾"x5½". Weight, 5½ oz.

Other Giant Blasting Supplies—Include Delay Action Electric Blasting Caps, Delay Electric Igniters, Electric Squibs, Magazines (Portable and Storage), Miners' Squibs, Tamping Bags, Thawing Kettles, etc.

Giant Blasting Machine No. 6

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THE GRASSELLI POWDER COMPANY

CLEVELAND, OHIO

New York Office: 117 Hudson Street

PITTSBURGH, PA.
UNIONTOWN, PA.
CUMBERLAND, MD.
CLARKSBURG, W. VA.
BIRMINGHAM, ALA.

CHICAGO, ILL.
PHILADELPHIA, PA.
POTTSVILLE, PA.
WILKES-BARRE, PA.
BLUEFIELD, W. VA.

For every blasting job there is a Graselli explosive exactly fitted for that job. We here list briefly the general characteristics of our various grades, and shall be glad to have one of our practical service men call and explain them to you in detail. He will also, if you desire, go over your blasting proposition with you and assist in selecting the grade best suited to conditions in your operation.

Nitro Glycerin Grade

Made in strengths from 20% to 60%.

A powerful, hard-hitting explosive for shooting hard, tough material. Not as suitable for underground work as other grades, as fumes are more objectionable. Can be shot successfully in wet holes.

Made in low-freezing and straight grades. 1¼ x 8 inch cartridges pack 100 to the 50-pound case; other sizes in proportion.

Gelatin Grade

Made in strengths from 30% to 75%.

The ideal explosive for wet work and where ventilation is not good. It is free from objectionable fumes and particularly adapted to tunnel work, shaft sinking, etc. Its plasticity enables it to be effectively loaded in upward-slanting or even in vertical overhead holes.

Made in low-freezing and straight grades. Averages 88 1¼ x 8 inch sticks per 50 pound box; other sizes in proportion.

Ammonia Grade

Made in strengths from 20% to 60%.

A general, all-around explosive. Its action is not as quick or shattering as the above grades, producing more of a lifting and heaving action, and therefore more desirable for many classes of work. It is less impervious to water than nitro glycerine grade, but the fumes are less objectionable.

Made in low-freezing and straight grades. 1¼ x 8 inch sticks pack 100 per 50-pound case; other sizes in proportion.

Special Grades

We also manufacture special grades to meet certain special conditions. They vary as to speed, expansion, etc., according to the requirements of the job for which they are to be used.

Blasting Powder

Made in various granulations from CCC which is of slow, heaving action, to FFFF, for shooting material requiring a sharp, quick and more shattering action.

Blasting Supplies

Blasting Caps.

Electric Blasting Caps—Copper or Iron Wires—Various Lengths.

Safety Fuse—All Grades.

Cordeau-Bickford—The Detonating Fuse.

Cordeau Accessories.

Blasting Machines—For Firing Electric Blasting Caps—Capacities 1 to 150 holes.

Rheostats—For Measuring Strength of Blasting Machines.

Galvanometers—For Testing Blasting Circuits.

Cables, Lead and Connecting Wire, etc.

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HERCULES POWDER CO.

WILMINGTON, DELAWARE

BRANCH OFFICES

Allentown, Pa. Birmingham, Ala. Buffalo N. Y. Chattanooga, Tenn. Chicago, Ill. Denver, Colo. Duluth, Minn. Hazleton, Pa. Huntington, W. Va. Joplin, Mo. Los Angeles, Cal. Louisville, Ky. New York City Norristown, Pa. Pittsburg, Kan. Pittsburgh, Penna. Pottsville, Penna. St. Louis, Mo. Salt Lake City, Utah San Francisco, Cal. Wilkesbarre, Pa.

Explosives, Blasting Supplies and Flotation Oils

Hercules Special No. 1

Because of its high cartridge count and low cost per cartridge, Hercules Special No. 1 is more economical on work for which it is suited than ordinary dynamite. There are about 1/3 more cartridges of Special No. 1 in a box than there are of ordinary dynamite in the same size cartridges. Hercules Special No. 1 frequently replaces 40% dynamite, cartridge for cartridge at a saving of approximately 25 per cent. Special No. 1 is a "bulky" explosive, hence not as good as gelatin where a concentrated charge is desired, as in tunnel driving in hard tight rock; however, for quarrying, open pit mining, road building and some underground work it is both effective and economical.

Hercules Special No. 2

Hercules Special No. 2 is similar to Special No. 1, but is not quite as strong. Special No. 2 is usually more economical for blasting gypsum, clay, shale and some of the easier-breaking rock formations. It is also well suited for nearly all agricultural blasting. It has the same high cartridge count as Special No. 1 but costs less per pound and per cartridge. On work for which it is suited, no high explosive on the market is more economical than Hercules Special No. 2.

Hercules Gelatin Dynamite

Hercules Low Freezing Gelatin Dynamite is distinguished by plasticity, high density, imperviousness to water, and freedom from noxious fumes. It is made in strengths from 25% to 75%.

Hercules Gelatin is good for wet work, or for use where ventilation is poor. Its plasticity enables it to be loaded easily and effectively in holes having an upward slant, and the density and plasticity make it extremely well adapted for tight blasting in hard rock, such as tunnel driving, shaft sinking, etc.

Packed in standard cartridges, 50 lbs. to the case.

Extra (Ammonia) Dynamite

Hercules Low Freezing Extra Ammonia Dynamite is made in strengths from 15% to 60%. It is less expensive than the Gelatin or Straight Nitroglycerin Dynamites and is recommended for mining, quarrying, digging wells, road and railroad construction, clay blasting and mud capping. It is not as waterproof as Gelatin or Straight Nitroglycerin Dynamites, but this defect is largely overcome by double dipping in paraffine. Packed in standard cartridges, 50 lbs. to a case.

Straight Nitroglycerin Dynamite

Hercules Low Freezing Nitroglycerin Dynamite is manufactured in strengths from 15% to 60%. It is suitable for work where a strong and quick explosive is required, and is, therefore, recommended for all kinds of hard, tight work where finely broken material is desired, and where the ventilation is good. It is also adapted for mudcapping, scrapping boilers and castings, propagated ditch and canal excavation. Packed in standard cartridges, 50 lbs. to the case.

Blasting Gelatin

Blasting Gelatin is the strongest, quickest and most waterproof explosive manufactured for commercial purposes, having a strength of 100%. Hercules Blasting Gelatin is especially adapted for use in cut holes, hard rock tunnel rounds, loads at the bottom of deep well-drilled holes, submarine blasts in hard rock, and as a primer for gelatin under special conditions. Packed in standard cartridges, 50 lbs. to the case.

R. R. P.

Hercules R. R. P. belongs to the class of explosives known as granular dynamite, often called Judson. It is best adapted for use in soft seamy material and for large tunnel or "coyote hole" blasts in hard rock. Packed in paraffine paper bags containing 12½ lbs. The standard case holds four of these bags, making a net weight of 50 lbs.

HERCULES BLASTING SUPPLIES

Hercules Blasting Machines

An apparatus for generating electric current used in firing electric blasting caps, squibs, and igniters; made in six sizes with capacity for detonating from three to one hundred and fifty caps in series.

Blasting Machine	Capacity
Midget—Pocket Size.	3 Electric Blasting Caps
No. 2	10 Electric Blasting Caps
No. 3	30 Electric Blasting Caps
No. 4	50 Electric Blasting Caps
No. 5	100 Electric Blasting Caps
No. 6	150 Electric Blasting Caps

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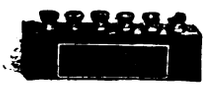
Galvanometers

A reliable and compact instrument for testing electric blasting circuits, electric blasting caps, and for locating breaks, short circuits, faulty connections. Weight 1 pound.

Hercules Rheostats

A small instrument offering the easiest and most effective means of testing the strength of a blasting machine without actually firing a series of electric blasting caps. This instrument gives a resistance equal to from 5 to 100 electric blasting caps, with 30 ft. copper wires.



Electric Blasting Caps

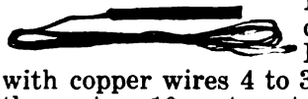
These are used to detonate charges of high explosives by means of electricity. They are made in two strengths, No. 6 and No. 8. These are furnished with insulated copper wires from 4 to 30 ft., or with iron wires from 4 to 8 ft. Packed 25 or 50 to the carton, 10 cartons to the case.

Electric Squibs

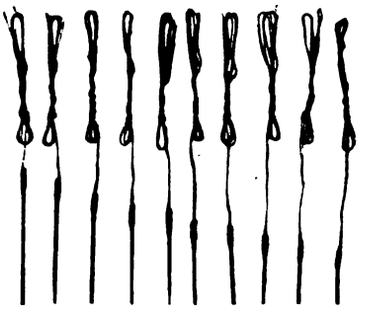
Hercules Electric Squibs are similar in appearance to Electric Blasting Caps, and are used to fire charges of blasting powders. Electric Squibs are made with 4 to 8 ft. iron wires, and 4 to 30 ft. copper wires. Packed 25 and 50 to the carton, 10 cartons to the case.

Delay Electric Blasting Caps

These are made in two delays. Three different periods can be obtained by using regular Electric Blasting Caps in the same circuit. Delay Electric Blasting Caps are made with copper wires 4 to 30 ft. Packed 25 and 50 to the carton, 10 cartons to the case.



Delay Action Electric Exploders



A combination Electric Igniter, Fuse and Blasting Cap, properly waterproofed, designed to fire charges in rotation by electricity, made in ten different delay periods. Furnished with copper wires, length 4 to 20 ft. Packed 25 and 50 to a carton, 10 cartons to the case.

Delay Electric Igniters

These igniters are similar to delay action exploders, made in six delays and used for firing charges of black powder in rotation. If desired, blasting caps may be crimped on the end of the igniter and used to fire high explosives. Furnished with copper wires 4 to 20 ft. Packed 50 to a carton, 10 cartons to a case.

Leading Wire

Hercules Leading Wire is an insulated copper wire (No. 14 B. & S. gauge) used for connecting electric blasting caps to the blasting machine. It is furnished in coils from 200 ft. to 500 ft.

Connecting Wire

Hercules Connecting Wire is used to join the wires of electric blasting caps. It is a high grade insulated copper wire (No. 20 B. & S. gauge), and is put up in one and two pound spools.

Blasting Caps

Blasting Caps are used to detonate charges of high explosives. As the efficiency of any high explosive depends on the initial detonation, we do not recommend caps smaller than Hercules No. 6.

Standard sizes Nos. 6 and 8. Packed 100 in a box, 5 to 50 boxes in a case.

Safety Fuse

The Hercules Powder Company carries all standard brands of fuse. These are adapted to all kinds and conditions of work. All brands have definite burning speeds, and are packed in coils of 100 ft. Cases contain from 5 to 60 coils.

Cordeau Bickford Detonating Fuse

Cordeau is a fuse that detonates throughout its entire length, and is particularly effective in large charges of explosives. It is waterproof. Cordeau is wound on spools containing from 200 ft. to 500 ft. each, and it may be shipped by express.

Cap Crimpers

Hercules Combined Fuse Cutter and Cap Crimpers are especially constructed pliers made for the purpose of fastening blasting caps securely to fuse. They are equipped with a special fuse cutter, and one handle is made round and pointed for punching holes in sticks of dynamite in which the detonators are placed. These crimpers are nickel-plated, packed in cartons, 12 to the box.

Storage Magazines

The Hercules Powder Co. carries a complete line of sidewalk and steel storage magazines, having a capacity of from 1 to 924 fifty lb. dynamite cases.

Tamping Bags

Hercules Tamping Bags are made of heavy water resisting paper. They are very convenient and inexpensive. Made in sizes from 1″ x 8″ to 2″ x 18″. Packed in bales containing 5,000.

Consult with the Hercules Service Division on All Your Blasting Problems. For Further Detailed Information Write for Our Book, "Hercules Products"

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ILLINOIS POWDER MFG. COMPANY

General Offices
1548-52 Pierce Building, ST. LOUIS
Works: GRAFTON, ILLINOIS
Branch Offices

Steger Bldg., 28 E. Jackson Bl. CHICAGO
1419 Central Bank Bldg. MEMPHIS, TENN.
406 Victor Bldg. KANSAS CITY, MO.

And Many Other Distributing Points

Makers of

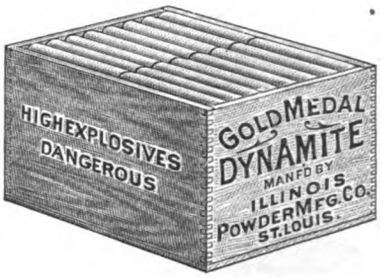
"Gold Medal Dynamite"

Manufacturers Also of

BLACK DIAMOND PERMISSIBLES AND BLASTING SUPPLIES——BLASTING POWDER

"GOLD MEDAL" DYNAMITE
A variety for every need.

"GOLD MEDAL" GELATIN
All Grades. All Strengths.

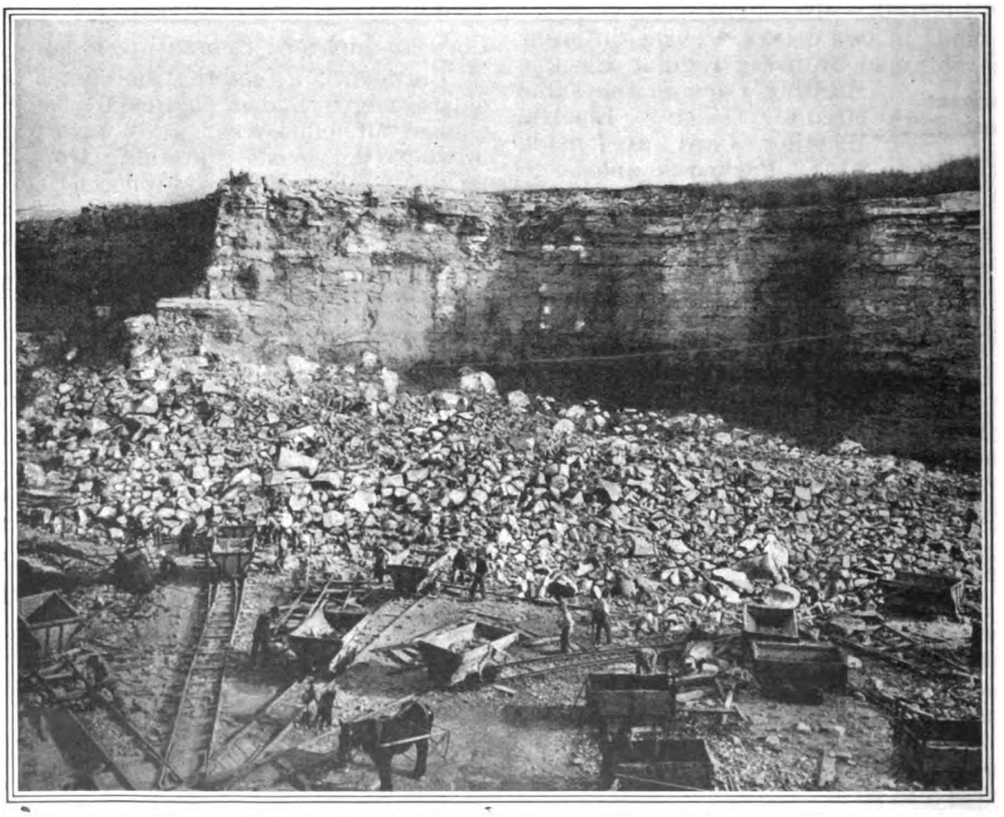


"GOLD MEDAL" PRODUCTS are Dependable—Uniform.

No requirements too small to receive our careful attention.
No demand too large for our facilities.

BLASTING SUPPLIES

The Illinois Powder Mfg. Co. carries a complete stock of Blasting Machines, Blasting Caps, Safety Fuse, Cordeau-Bickford Detonating Fuse, Electric Blasting Caps, Leading and Connecting Wire, Thawing Kettles, and all other Blasting Supplies. Every order is given careful and prompt attention. Your requirements are solicited.



THE RESULT! It Certainly Shows For Itself

"GOLD MEDAL" DYNAMITE—"Stronger and Goes Further"

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THE ENSIGN-BICKFORD CO.

SIMSBURY, CONN.

Manufacturers of

Safety Fuse For All Purposes and Cordeau-Bickford Detonating Fuse

CORDEAU-BICKFORD

Cordeau-Bickford is a detonating safety fuse consisting of a lead tube filled with trinitrotoluene. It has been manufactured by The Ensign-Bickford Company during the past seven years and may be obtained direct or through any of the explosive companies.

Cordeau is run from the top to the bottom of the drill hole in contact with the explosive charge so that it acts as a continuous detonator, with the result that a more complete and quicker detonation of the explosives is obtained. On account of this, there is a greater shattering effect on the rock, and the secondary blasting is therefore reduced.

Blast of 156 well drill holes in an Ohio stone quarry—average depth 26 ft. Cordeau-Bickford used to detonate the explosive charges

This type of detonator is waterproof, safe and easy to handle, and will explode a charge of explosive throughout its entire length and also any number of separate charges instantaneously.

Cordeau-Bickford cannot be set off by fire, friction, or any ordinary shock.

Cordeau is particularly adapted to well drill blasting where large columns of explosives are fired, where it is desirable to break the charge in the drill hole, or where a great many holes are to be fired at one time.

Cordeau is also used in the "Coyote" or Tunnel and Pocket method of blasting.

The explosive manufacturers use Cordeau for determining the rate of detonation of their explosives.

Write for booklets on Cordeau and Deep Well Blasting.

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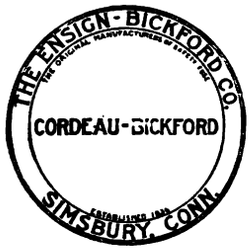
THE ENSIGN-BICKFORD CO.

SIMSBURY, CONN.

Manufacturers of

Safety Fuse For All Purposes
and
Cordeau-Bickford Detonating Fuse



It is essential for the purpose of safety and economy to purchase a brand of fuse adapted to the work for which it is to be used.

In quarrying, the work may be dry, damp, or wet; while in metal mining, the work is generally either damp or wet. Dry work means that the fuse does not come in contact with moisture; damp work means that there is moisture present either in the drill hole or in the tamping material (mud-capping, for instance, is generally classed as damp work); and wet work means that the fuse is actually exposed to the direct action of water in the drill hole. In underground work of various kinds, the following characteristics in fuse, in addition to the waterproofing quality, are important: Regularity in burning, freedom from lateral sparking and excessive smoke, ability to withstand reasonable tamping, flexibility, and an exterior white finish which makes it easily distinguishable in the dark.

The standard burning speed of all our brands of fuse at sea level, with the exception of Charter Oak and Clover, is ninety seconds per yard when burned in the open with an allowable variation of 10% either way from standard. Clover and Charter Oak have a standard burning speed of one hundred twenty seconds per yard under the above conditions with an allowable variation of 10% either way from standard.

TAPED FUSE

The original waterproof fuses were all of the tape variety. Low temperatures affect the pliability of taped fuse and in work done on the surface in cold weather, the countered fuses such as Beaver, Charter Oak, Crescent, and Clover are best adapted in preference to Single Tape or Double Tape.

Single Tape

For use in dry or damp work.

Double Tape

For use in wet work. This fuse has two tape coverings which add strength as well as waterproof qualities.

COUNTERED FUSE

Beaver and White Charter Oak

For dry or damp work, Beaver or White Charter Oak is quite generally used, Beaver being selected by those who have preference for the ninety second standard burning speed, and White Charter Oak by those who prefer the slower standard of one hundred twenty seconds per yard.

Gray and Black Charter Oak

Gray and Black Charter Oak are a later development in manufacture which has enabled us to improve the waterproof quality without adding to the cost. Where the requirements for waterproofing are beyond the limits of Beaver or White Charter Oak, we recommend the adoption of Gray or Black Charter Oak.

Crescent, Anchor, Clover

Where the two principal elements are waterproofing and regularity of burning speed, Crescent or Anchor are usually preferred; but where other considerations enter in, such as freedom from side spit, freedom from excessive smoke, and economy of time due to slower burning speed, Clover is preferred because it has even greater waterproof qualities than Crescent, and has, in addition thereto, the above mentioned advantages. The paper tape used on Clover enables the fuse to be subjected to extreme climatic changes and long storage without deterioration.

Avoid lacing, half hitching or the kinking of fuse, especially when the fuse is going to be used in a wet drill hole.

Price lists, sample cards, and further information will be gladly furnished on application.

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SECTION XVII
Ore Dressing and Milling

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Allen Cone Company
Allis-Chalmers Mfg. Co.
American Pulverizer Co.
Automatic Weighing Machine Co.
B. & W. Oil-less Conveyor Co.
Braun Corporation
Buchanan, C. G. Co., Inc.
Chalmers & Williams
Colorado Iron Works Co.
Deister Concentrator Co., The
Deister Machine Co.
Dings Magnetic Separator Co.
Dodge Sales & Engineering Co.
Goodrich, B. F. Rubber Co., The
Gruendler Patent Crusher & Pulverizer Co.
Hardinge Company
Harrington & King Perforating Co.
Hendrick Manufacturing Co.
Hendy, Joshua, Iron Works
Hyatt Roller Bearing Co.
Jeffrey Manufacturing Co., The
Krogh Pump and Machinery Co.
Link-Belt Company
Ludlow-Saylor Wire Co., The
Magnetic Manufacturing Co.
Merrick Scale Mfg. Co.
Metal Supply Co.
Midwest Forge & Steel Co.
Mine & Smelter Supply Co., The
New York Belting & Packing Co.
Newark Wire Cloth Co.
Nortmann-Duffke Co.
Pettibone Mulliken Co.
Quaker City Rubber Co.
Robins Conveying Belt Co.
Schaffer Engineering & Equipment Co.
Scullin Steel Co.
United States Rubber Co.
Webster Mfg. Co., The
Weller Manufacturing Co.
Williams Patent Crusher & Pulverizer Co.
Worthington Pump and Machinery Corporation

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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EDITOR'S NOTE: It is our opinion after consideration of the various criticisms offered on the first edition, that, much as we would like to do so, we must refrain from the inclusion in the technical sections many of the purely academic discussions of abstract theories, which, although they are of interest to the mining man, nevertheless are of little practical value. Since this Catalog is primarily for the use of the practical man, we are constrained to replace the extremely interesting discussions of the so-called "Crushing Laws" with data which will be of more service to our clients in the actual pursuit of their professions.

For the benefit of those who may wish to study the theory of crushing, and who haven't the first edition of the MINING CATALOG, we are including herewith references to the sources from which we obtained the material for the compilation of this discussion.

"The Law of Crushing," by H. Stadler, in the Engineering & Mining Journal. Mr. Stadler refers to "Dingler's Polytech Journal," 1884, Vol. 251; "Engineering & Mining Journal," December 14, 1912, and May 24, 1913; "Trans. A. I. M. E.," Vol. 37, February, 1914; "The Crushing Surface Diagram," Engineering & Mining Journal, 1914; Richards' "Ore Dressing," and "Crushing Surface Diagrams," by A. O. Gates, Engineering & Mining Journal, February 25, 1922.

The last mentioned reference claims that both Rittinger's and Kick's "Laws" are incorrect, which in our opinion is sufficient justification for the omission of the discussion from this section.

COMPARISON OF GYRATORY AND JAW CRUSHERS*

Abstract from an article by L. H. Wollenberg, in the Engineering & Mining Journal.

To show that each type of crusher has its field in which it is superior, and to define the limits of each, is the purpose of this treatise.

Aside from some modifications and refinements, these machines are built today in a manner similar to that of the earlier designs. There are improvements in design that have become more or less standard with certain manufacturers.

Of greater importance than the peculiar advantages and disadvantages inherent in the different types of machines (generally well recognized), are the characteristics of each machine for a particular size and service.

Table 1 has been prepared from actual data furnished by manufacturers for average conditions with hard friable rock. The machines quoted to deliver a certain sized product are the medium sizes adapted to that product. The particulars of the 36 x 282-in. and the 42 x 345-in. gyratory crushers are only approximate, as the largest standard size manufactured at the date of writing was 24 x 198-in. Larger crushers have been built to special design.

Size of Feed

It develops from inspection of the table that the gyratory is a machine of greater weight, capacity and horse power for a given size of feed and product than the jaw crusher. In other words the design of the gyratory is dependent upon the width of the feed opening, while in the jaw type the width and the length of the feed opening can be varied independently of each other. This characteristic is important in defining the field of each type.

Weight, Capacity and Horse Power

Table 2 indicates that in comparison with the weight and horse power, which are greater in the gyratory than in the jaw crusher for a given size of feed, the capacity is much greater still. The reason assigned for this is the nature of the crushing principles involved in the action of the gyratory, namely the utilization of the "beam" principle in the gyratory as compared to the simple crushing by compression in the jaw type.

The gyratory is more economical of power due to its continuous action, whereas the jaw type has to overcome at each stroke the inertia of the heavy and rapidly reciprocating parts.

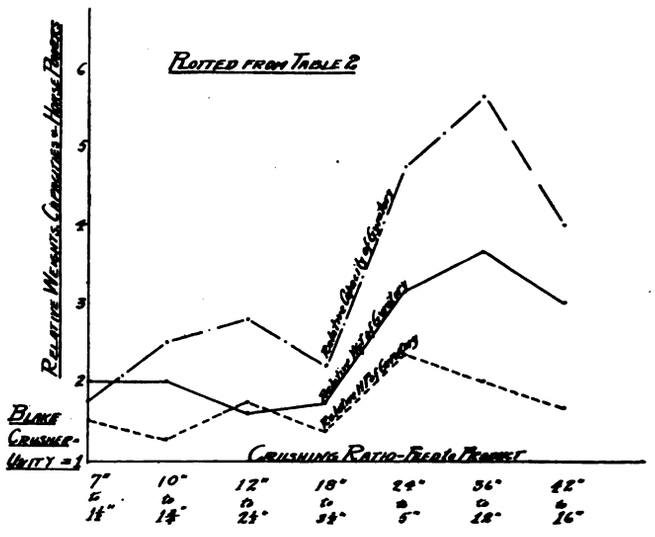

TABLE 1. COMPARATIVE FEATURES OF JAW AND GYRATORY CRUSHERS

Crushing from.....	7 to 1½ in.		10 to 1¾ in.		12 to 2½ in.		18 to 3½ in.		24 to 5 in.		36 to 12 in.		42 to 16 in.	
Type of crusher.....	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory	Blake	Gyratory
Size of feed opening in inches	10x7	7x56	20x10	10x80	24x12	12x88	36x18	18x136	36x24	24x198	42x36	36x282	60x42	42x345
Capacity in tons per hour....	4	7	12	30	25	70	60	130	85	400	160	900	300	1200
Weight in tons.....	4	8	9	18	15	24	29	50	30	95	55	200	100	300
Hourly capacity ÷ tons weight.	1	0.87	1.25	1.66	1.67	2.91	2.07	2.60	2.83	4.22	2.90	4.5	3	4
Installed horsepower.....	8	12	20	25	30	50	65	90	65	150	100	200	150	250
Hourly capacity, installed horsepower	0.5	0.58	0.60	1.20	0.8	1.40	0.92	1.44	1.31	2.67	1.60	4.5	2	4.8
Height in feet (discharge spout to feed floor).....	3	5½	3	7½	5	8	6	10	6	15	7	23	8	26
Width in feet (including the pulleys).....	6½	10	7	13	8	13	13	13	13	20	13	27	15	30
Length in feet (overall).....	5½	5	9	6	10	6	12	12	12	12	15	18	16	21

*L. H. Wollenberg in Eng. and Min. Journal.

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Comparison of Operating Advantages

The **floor space** for machines of equal capacity is about the same, but the advantage lies with the **jaw crusher** in the matter of height and **head room** required.

The **gyratory,** owing to the beam action in crushing gives a more cubic and therefore a **more uniform product.**

TABLE 2. RELATIVE WEIGHTS, CAPACITIES AND HORSEPOWER

The Blake Crusher being taken as unity in each case

Crushing from..	7 to 1½ in.	10 to 1¾ in.	12 to 2½ in.	18 to 3½ in.	24 to 5 in.	36 to 12 in.	42 to 16 in.
Relative weight of gyratory..	2.0	2.0	1.60	1.72	3.16	3.65	3.00
Relative horsepower of gyratory	1.50	1.25	1.66	1.39	2.32	2.00	1.68
Relative capac'y of gyratory..	1.75	2.5	2.80	2.17	4.72	5.62	4.0

There is less actual **wear on the parts** of the **jaw crusher,** due to the grinding action in the gyratory. The liners of a gyratory cannot be reversed as in a jaw type. Therefore **renewals** are more expensive in the gyratory type.

Attendance is the same, giving the advantage to the **gyratory** on account of its greater capacity.

Repairs

Repairs are more difficult and more expensive in gyratory crushers. A well designed jaw crusher is easier to keep in order.

As regards vibration the gyratory is superior.

The critical mechanical feature of the gyratory is the eccentric drive on the lower end of the main shaft. With hard rock and heavy feeding it requires efficient lubrication to keep the bearings cool. A well designed Blake crusher is easier to keep in order. The introduction of steel castings for the main frame of the jaw crushers has increased the strength and lessened the weight of that important part. As regards vibration during operation the gyratory is superior, as it runs very steadily.

The consideration of relative merits for a specified capacity, and the comparisons drawn therefrom are all on the basis of a given size of feed and product. It would be desirable to compare the two types on the basis of given capacity as well as size of feed and product, but this is not possible. When we designate the feed and product, the size and capacity of the appropriate crusher of each type is determined thereby, and these vary widely for the two types. The bearing that the required capacity has upon the comparison of merits, although left for the last, is all important, as will be shown.

Consider the case in the first column of Tables 1 and 2. This is the only case of those tabulated in which the gyratory does not excel in capacity per ton weight of machine. If, however, a particular installation required the capacity afforded by the 7x56-in. gyratory (seven tons per hour), it might be selected in place of two 10x7-in. Blake crushers, because of the economy of one machine, one foundation, and one attendant. If, however, advantages are to be gained, as in small stamp mills, by dividing the work between several small crushers so as to avoid conveying the crushed material and gain bin storage without additional height, two small Blake crushers might be selected in preference to one gyratory. It should be noted that the relative weight of the two types is not an exact index of the relative first cost, because the gyratory crushers are sold at a higher price per pound than the Blake type. There are other factors affecting first cost besides the price of the machine at the manufacturer's works.

In Table 3 the distribution of sizes in run-of-mine ore is obtained from experience.

TABLE 3. SIZE ANALYSIS

Crushing Plant designed for 125 tons per hour

	Tons per Hour Between			
	36 and 12 in.	12 and 3 in.	3 and 1¾ in.	1¾ in. and under
Run of mine.....	55	40	15	15
Feed to first crusher.....	55	..	..	..
Product of first crusher....	..	30	15	10
Feed to second crusher....	..	70	..	..
Product of second crusher.	..	..	30	40
Feed to third crusher.....	..	..	60	..
Product of third crusher...	..	..	..	60

Blake Preferred as Initial Crusher

Taking the required capacities and duties as arrived at in Table 3, and referring to Table 1, it is apparent that we would select the 42x36-in. Blake crusher for the initial breaker. This machine has excess capacity over what is required, but not such enormous excess cost and capacity as a gyratory for the same work. For the secondary crushing one 12x88-in. gyratory is strikingly superior, as it would require three 24x12-in., or two 40x12-in., or two 36x18in. Blake crushers for the same capacity. For the final crushing two 8x60-in. gyratory crushers would be indicated.

If the ore formation and conditions of mining and transportation were such that an initial crusher to receive pieces 24x36-in. was sufficiently large, it would be found, upon making a size analysis similar to that shown in Table 3 for 36x42-in., that one 36x24-in. Blake machine crushing to 4-in., followed by two 10x80-in. gyratory crushers each giving a product to pass a 1¾-in. ring, would meet the conditions.

The conclusions reached above are in accordance with the most advanced practice. The economy of breaking by crusher over bulldozing and sledging is beginning to be appreciated. Recent installations in South Africa employ large Blake crushers for initial breakers, followed by gyratory machines preliminary to stamp milling. A notable installation in the United States is that of a 60x42-in. jaw crusher capable of breaking down to 16-in the largest pieces of hard iron ore that can be handled by a 70-ton steam shovel. Other plants where economies have been secured by introducing large initial crushers of the jaw type are the Granby mines, Phœnix, B. C., the British Columbia Copper Company and the Natomas Consolidated of California.

In conclusion it may be said that while each type has a field in which it is superior, no sharp lines can be drawn because of the many factors involved. It is believed, however, that with the aid of the data here presented an investigation along the lines indicated will quickly indicate the most desirable machine for any particular service.

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CAPACITY AND HORSE POWER OF CRUSHING ROLLS

The Speed and Capacity Diagram and Horse Power Table for rolls with smooth shells and for rolls with corrugated shells are the results of numerous tests that have been made to determine the best speeds for rolls of various diameters and sizes of feed.

The diagonal lines in the diagrams represent standard rolls of the diameters indicated and show the limit of their gripping capacities at a nipping angle of 31 degrees and a crushing ratio of 1:4. The gripping limits are determined with the roll shells worn to a safe minimum thickness. Rolls with new shells will grip a proportionally larger size.

Below the feed size is given the ring size of the finished product in inches when crushing 1:4. The mesh of the screen corresponding with the product is also given in the smooth shell diagram.

The horizontal lines in the diagrams represent the peripheral speeds given at their left ends. The peripheral speeds are principally controlled by the size of the particles fed to the machine, the roll diameters and the nature of the rock. Rolls of large diameters can be run at considerably higher peripheral speeds than those having smaller diameters, due to smaller pressure per square inch and lower rubbing velocity in the bearings.

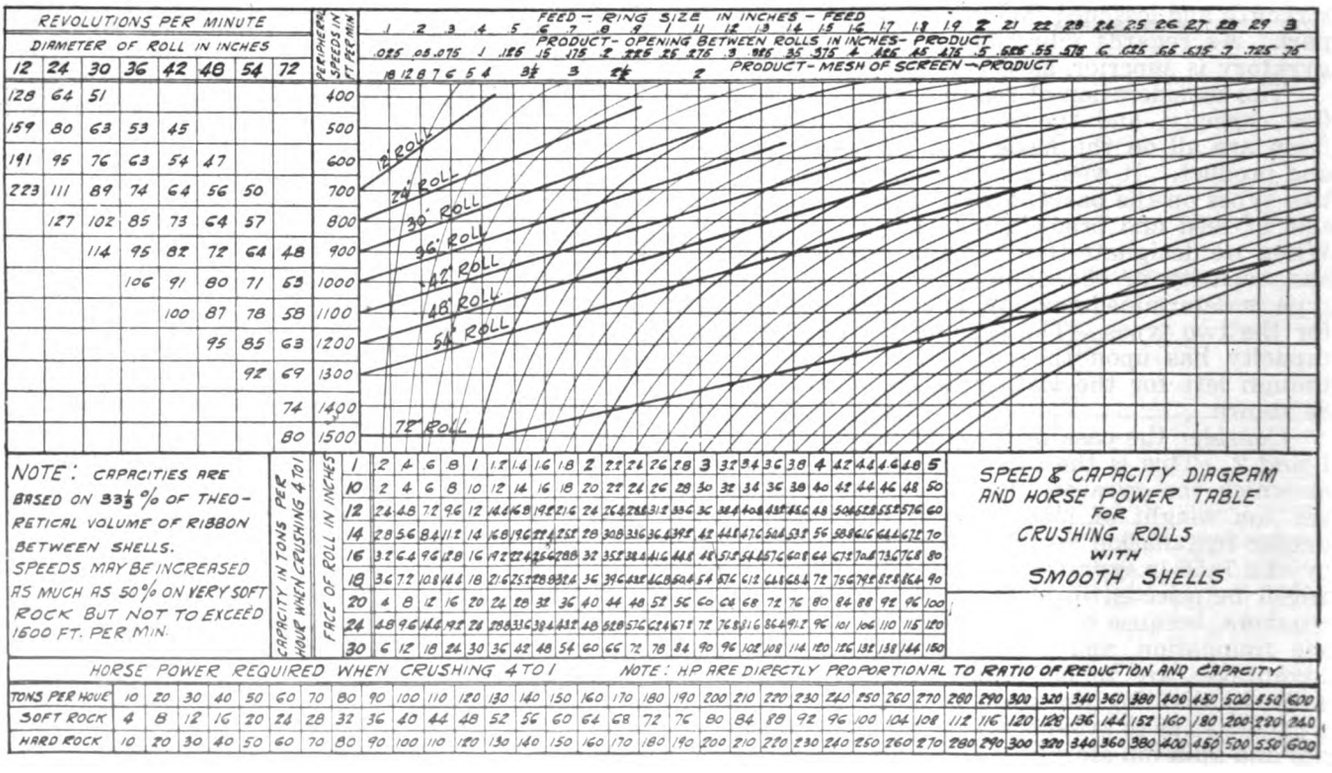
When crushing medium hard and hard rock, the rolls should be run at the speeds indicated in the diagrams.

For crushing soft or very soft rock the speeds may be increased as much as 50 per cent, but the peripheral speeds should in no case exceed 1,500 feet per minute for smooth rolls, and 1,300 feet per minute for rolls with corrugated shells; however, very good judgment must be exercised in speeding up rolls.

For convenience, the proper number of revolutions per minute for the various diameters of rolls are tabulated to the left of the corresponding peripheral speeds.

The parabolic curves indicate uniform capacity and their values in tons per hour when crushing to the size shown are given at the bottom of the diagram for different face width of rolls. These capacities represent 33⅓ per cent of the theoretical volume of ribbon between the roll shells, and are directly proportional to the peripheral speed and size of product.

The horse power required to run crushing rolls depends entirely upon the capacity or tonnage per hour, the ratio of reduction, the nature of rock and amount of loss by friction. Owing to superior design and to careful workmanship, the efficiency is about the same for the various sizes of these machines. This enables us to determine the horse powers for rolls of different diameters when crushing the same grade of rock under continuous even feed entirely by the tonnage and ratio of reduction.



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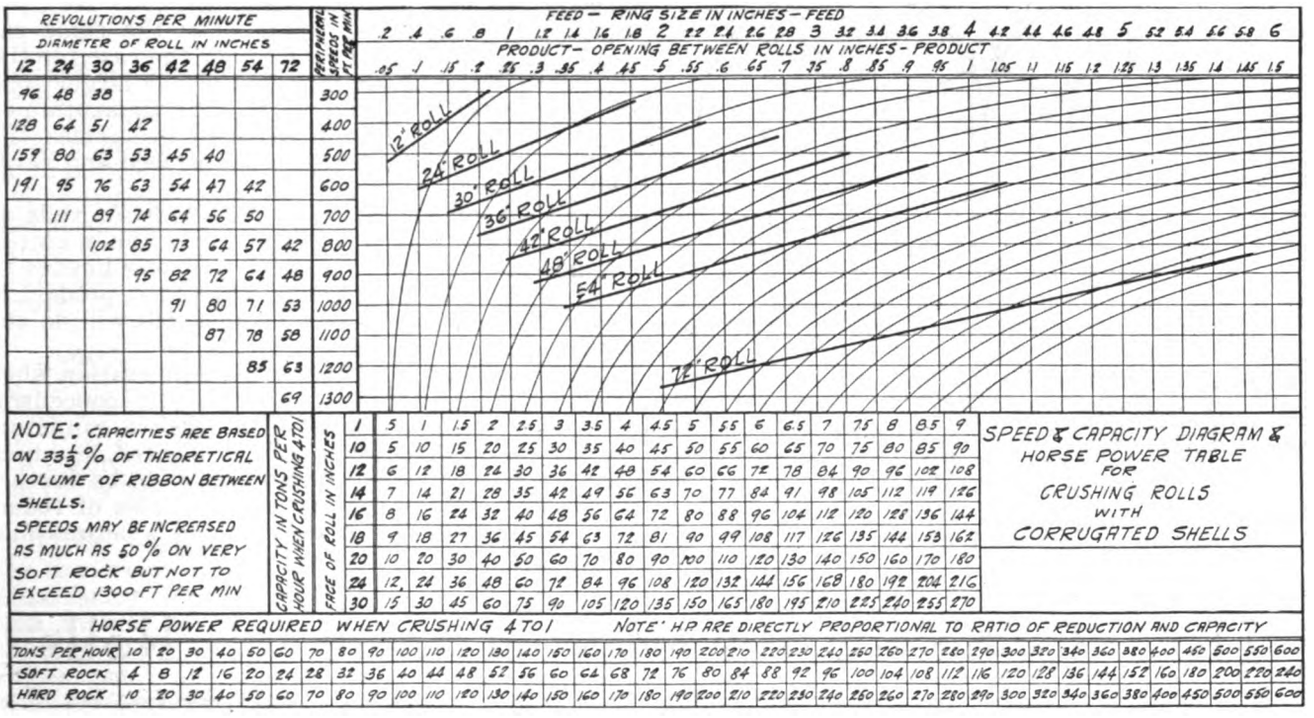
The horse power tables given with the diagrams have been checked by actual tests and will be found very reliable. The horse powers required for crushing both soft and hard rock are given for different capacities.

The use of the diagrams will be best explained by two examples. Let a case be assumed where it is necessary to feed medium hard rock 1.1″ in diameter. Directly below 1.1 is found the figure .275, which shows the resulting product in inches 1:4, which corresponds to particles of two mesh in size. Following down the vertical line below 1.1 we find that the smallest rolls with smooth shells which will grip this material is 30″ in diameter. From the point of intersection of the vertical with the diagonal for 30″ roll, following the nearest horizontal line to the left, we find that the peripheral speed should be 520 feet per minute. In the column showing the speed for the 30″ rolls, we find that they should run 65 R. P. M.

a product of 1.5 below, which is .5″ smaller than required. By reducing the feed size by this difference we obtain 5.5″. Taking this result as the feed size and following down midways between the vertical lines below 5.4 and 5.6 to the first diagonal line representing the 72″ rolls, which is the size roll to be used, and running along the nearest horizontal line, the diagram shows a peripheral speed of 875 feet per minute. Since the assumption is that soft stone is to be crushed, we may increase this speed to 1,000 feet, or 53 revolutions per minute.

The size of product is to be 2″. But, since the largest product listed on the diagram is only 1.5″, let us use for convenience the 1″. Following down the vertical below 1″ product until it intersects the 1,000 ft. per minute speed line and then proceeding along the intersecting parabolic curve, the table indicates a tonnage of 210 per hour for a 30″ face roll. The capacity, however, will be twice the



The nearest parabolic curve to the intersection referred to above if followed down to the border, shows in the line of figures for 14″ face, that 14 tons can be crushed per hour.

In the horse power table we find by interpolation that 10 H. P. will suffice to run the rolls.

Example 2: Let it be required to produce under a perfectly continuous even feed, about 600 tons of 2″ material per hour. The rock fed being soft limestone 6″ ring size.

In the diagrams for rolls with corrugated shells we find a feed of 6″ ring size listed with figure as the product is 2″ instead of one. As stated, the material will be fed continuously and evenly; hence we may take 50 per cent of the ribbon volume, which gives us a total capacity of 630 tons, say safe 600 tons per hour.

The horse power table calls for 240 H. P. for crushing 600 tons of soft rock in one hour at a reduction ratio of 1:4. Since the ratio in question is 1:3, 180 H. P. is all that is needed to drive the rolls. Under very favorable conditions 150 H. P. would probably do.

Worthington Pump & Machinery Corp.

DATA FOR FIGURING CAPACITY OF ROLLS

The capacity of Rolls is influenced by the character of the material and the fineness of reduction. It is manifestly impossible to anticipate the various conditions incident to the reduction of ores, owing to the wide range in their character. Therefore, a reliable formula for calculating capacity which is applicable to all conditions is impossible, but since the capacity of crushing rolls is in direct ratio to

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the width of face and peripheral speed we give the following:

$$\frac{T \times W \times S}{1728} = \text{cubic feet per minute}$$

T = Distance in inches roll faces are set apart
W = Width in inches roll faces
S = Peripheral speed inches per minute.

This gives the theoretical capacity which, on account of irregularity in feed, etc., should be divided by 4 to give the actual capacity.

Fig. No. 3 illustrates the method of determining the maximum size of feed for Rolls of a given diameter. In the following table these sizes are given for our standard Rolls.

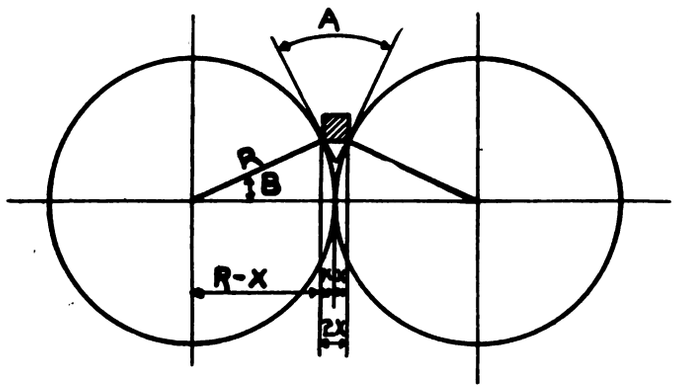


Fig. 3.

Let R = Radius of Roll
A = Wedge Angle (31°) = "Angle of Nip"
B = Friction Angle, (16° 45′)
Coef. of Friction is .3
Size of Pieces Rolls will take = 2X

$$\text{COS.B.} = \frac{R-X}{R}$$

Diam. of Rolls	Size of Pieces	
9″	.26″	Plus the spread of the Rolls equals maximum size of pieces which Rolls will take.
12″	.48″	
18″	.72″	
24″	.96″	
26″	1.04″	
30″	1.20″	
36″	1.44″	
40″	1.60″	
42″	1.68″	
48″	1.92″	
54″	2.16″	
72″	2.88″	

To the above maximum size of feed should be added the opening between roll faces, for instance—the maximum size piece which should be fed to rolls 30 inches diameter set ¼ inch apart would be 1.45 inches.

The peripheral speed at which rolls for fine crushing are usually operated is about 1000 feet per minute for all sizes up to 54 inches diameter; when crushing coarse or for sizes larger than 54 inches the speed is reduced to 700 or 800 feet per minute.

It might be inferred that if all sizes of rolls are operated at the uniform speed of 1000 feet per minute, a 30x16″ Roll would have the same capacity as a 42x16″, but such is not the case for the reason that the revolving parts of the larger rolls having greater mass and weight, the momentum or kinetic energy stored up in them overcomes the sudden shocks due to irregularity in feed and hardness of material with greater ease.

The economical range of reduction for rolls of course varies to some extent with the material crushed but may be considered as being limited to from 12 to 16 mesh product; when finer product is required a ball granulator or tube mill will do the work at less cost.

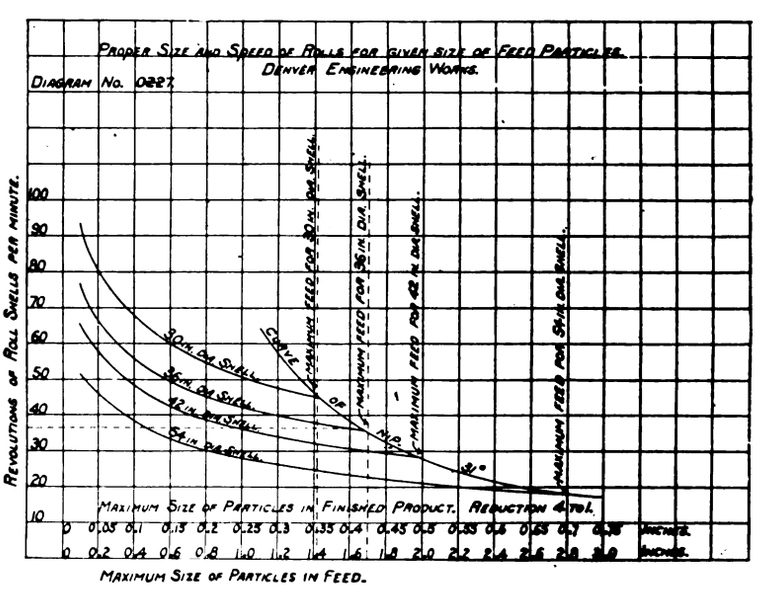
The best ratio of reduction in one operation when crushing ore for treatment by gravity concentration, where a granular product with a minimum percentage of fines or slimes is desired, is about four to one, but when the product is to be further reduced by tube milling or other process of reduction, a ratio of seven or eight to one is permissible.

Allis-Chalmers Mfg. Co.

How to Select the Proper Size of Rolls

First. There must be known the size of the feed. From this the minimum diameter of rolls is determined by referring to Diagram No. 0227. The size of feed is seldom over 1½ to 2 inches. If the pieces of ore are too large, they will not be caught or nipped by the shells, as the "angle of nip" is too great. The "angle of nip" is the angle formed by the tangents at the points where the particle of ore touches the shells. A, in Fig. 0230, is the angle of nip. For practical milling conditions, the maximum angle which may be used with safety is 31°. By increasing the distance between the shells the angle of nip is of course decreased, but this decreases the percentage of reduction for a feed of given size.

Second. The speed, which depends on the diameter of the rolls and the size of the feed, both the latter now known, is determined by reference to Diagram No. 0227.



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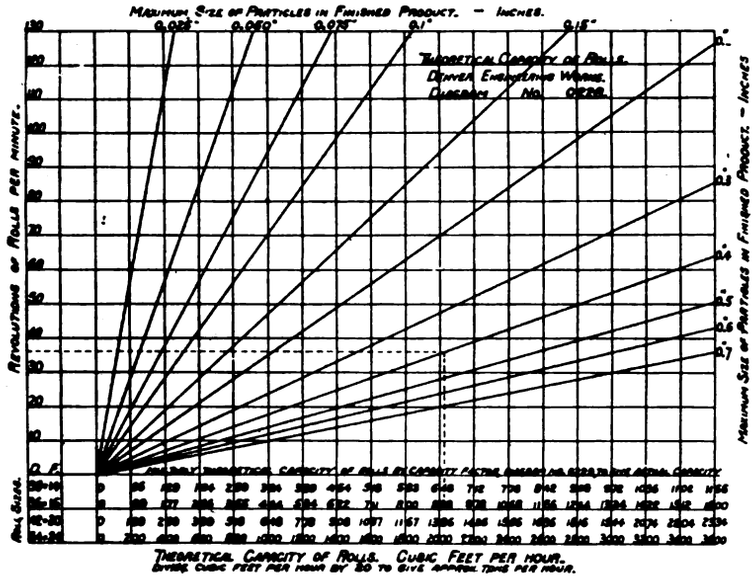

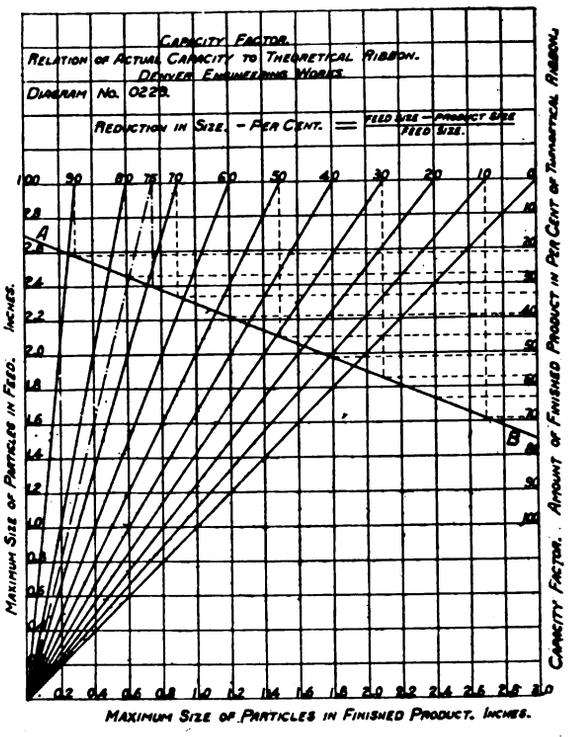

Third. Size of finished product. The reduction in size of the feed particles as they pass through the rolls must not exceed 4 to 1, if particles are ¼ inch or larger. This is equivalent to a reduction of 75 per cent. This means that 2-inch pieces must not be crushed in one stage to smaller than ½ inch, and if smaller product is desired, then the ½-inch product must be passed through a second set of rolls, and so on. Further, it is not advisable to crush finer than 0.04 inch with any set of rolls.

Fourth. Theoretical capacity, which depends on size of finished product and speed of rolls. Both being known, reference to Diagram No. 0228 gives the result. The theoretical capacity is equal to the theoretical ribbon of material passing through the space between the two shells.

Fifth. Capacity factor, which multiplied by the theoretical capacity, gives the actual capacity. This factor depends on the percentage of reduction in size of the feed particles as they pass through the rolls. One inch crushed to ¼-inch is 75 per cent. reduction. One inch crushed to ¾-inch is 25 per cent. reduction. Knowing the percentage of reduction, Diagram No. 0229 gives the capacity factor.

As crushed material is at least 50 per cent. voids, then the actual maximum capacity to be expected from rolls would be 50 per cent. of the theoretical ribbon. This would be true when crushing soft rocks and with a uniform and continuous feed. For hard rocks 33 per cent. of the theoretical ribbon is correct, but in practice 30 per cent. is safer.

Sixth. Actual capacity, which is found by multiplying the theoretical capacity by the capacity factor.

How to Use the Diagrams to Determine the Proper Size and Speed of Rolls

Assume the maximum size of feed cube to be 1.6 inches. Find 1.6 (Diagram .0227) in the lower horizontal line of figures marked "Maximum size of particles in feed." Follow the vertical line corresponding with 1.6 until it intersects the curve of nip—31°. This point indicates a roll shell larger than 30 inches and smaller than 36 inches diameter. The 36-inch should therefore be used instead of the 30-inch shell. In the same manner the diagram gives the proper diameter of roll shell to use for each size of feed, as follows:

For feed 2.8 to 2 inches.....use 54-inch roll shells
For feed 2 to 1.7 inches.....use 42-inch roll shells
For feed 1.7 to 1.4 inches.....use 36-inch roll shells
For feed 1.4 inches and smaller..use 30-inch roll shells

Next, the speed of the rolls is to be determined:

Find the size of feed 1.6 (Diagram 0227) in the lower horizontal row of figures; follow the vertical line for this size upward until it intersects the curve for the 36-inch roll shell; then follow the horizontal line passing through this point to the figures on the left, giving 36 revolutions per minute as the proper speed.

Next to be determined is the theoretical capacity:

From Diagram No. 0228 find the revolutions 36 in the left-hand vertical column of figures, follow the corresponding horizontal line to the right until it intersects the diagonal line for 0.4 size of finished product; from this point of intersection, follow the vertical line down to the figures at the bottom of the diagram, and in the horizontal row corresponding to the 36-inch size of roll will be found 888 cubic feet per hour as the theoretical capacity.

Having assumed the size of finished product to be 0.4 inches:

Find 1.6 (Diagram 0229) in the vertical column for maximum size of **feed,** follow horizontal line to the right until it intersects the vertical line for 0.4 finished product. Follow the diagonal line to percentage of reduction, equals 75. From 75, percentage of reduction, drop down to the line A—B, and from the point of intersection follow the horizontal line to the right to "Amount of finished product in percentage of theoretical ribbon," 30 per

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cent. This means that, when crushing a feed cube of 1.6 inches down to 0.4 inch, the actual crushed product will be 30 per cent. of the theoretical ribbon.

The actual capacity will be the theoretical 888 multiplied by the capacity factor, 30 per cent., equals 266 cubic feet per hour.

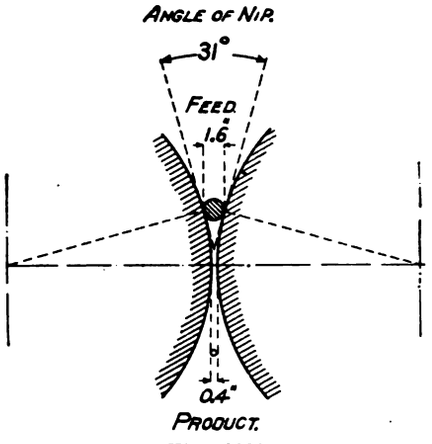
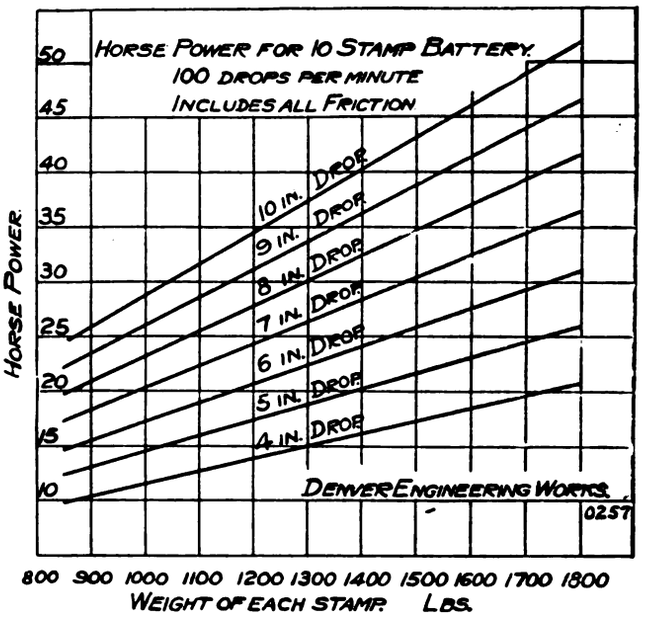


Fig. .0230



Courtesy Denver Eng. Works.

THE POWER-LOAD CURVES OF BALL MILLS

Millmen generally will agree that the more power a mill can be made to take the more tons of ore it will grind, other things being equal, which is not always easy or possible of accomplishment. In recent years surprising increases have been made in capacities of crushing machines; rolls, Chileans, and ball and pebble mills all show remarkable increases due to manipulation of the feed, sufficient power being available. I have no intention of discussing matters of tonnage in this short article, but wish to indicate something of the variation of power with variation of speed ,diameter, and ball or pebble load. This data should apply to rod mills as well.

The mechanics of the ball and pebble mill are simpler than for any other type of crushing machines; the power-consuming elements may be divided into two types capable of rather simple treatment. In crushers, rolls, roller types (Huntingtons, Chileans, and a multitude of variations), the differences in the crushing resistance of the mass being crushed affect the friction load in a variable and rather uncertain degree. In some types of crushing machines it will be conceded that high resistance against crushing, frequently or regularly, squeezes the lubricant from the bearings so that there is metal-to-metal contact at times; and this is a condition extremely difficult, if not impossible, of mathematical analysis.

I hold no brief for any purely theoretical school of reasoning; but if the application of theory will make it check with what experience has shown to be good practice, wider fields of application will be open. It is well to be able to predetermine some things about crushing machines, and about the only way this can be done is by the use of formulæ obtained by theoretical reasoning held in check by the results of practical work. A theory always ought to be checked against practice.

Power Consumed in Two Ways

Power is consumed by ball and pebble mills as (a) friction losses in bearings and gearing, and (b) energy spent upon the free balls or pebbles within the mill, and by them spent upon the ore, or other pebbles, or on the lining, or returned to the mill.

The variations in thickness of oil films in the bearings differ only slightly from no load to full load, and, except possibly in the main bearings, they are nearly constant for constant speed. Experience with steam engines under all load conditions has shown that, for constant speed, the friction loss is nearly constant at all loads; any statement by an engine manufacturer as to the mechanical efficiency of his engine at different loads will be based upon this fact. As the weight of the combined charge in ball mills is usually less than that of the mill parts carried by the trunnions, in the absence of specific data to the contrary one cannot be far afield in assuming that the friction load of these mills is practically constant for all loads at constant speed. There remains, then, the internal power consumption to be considered.

Some years ago in casting about for a method of studying the action in pebble mills without great outlay for apparatus it was found that some quantitative results of reasonable accuracy could be obtained from apparatus which at first was intended only for superficial and qualitative work. The average man without a laboratory at his disposal finds that to do experimental work in which variations in speeds are necessary a lot of pulleys are required, or a variable-speed motor is essential, and many difficulties are encountered which detract from the enjoyment, if not the accuracy, of the work. My apparatus eliminated all outside difficulties, as well as the friction in the driving mechanism, and I was able to measure power relatively, if not actually, in an entirely satisfactory way.

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The ball mill itself was 4 in. in diameter and about 3 in. wide. It was made of a marshmallow box, the glass from a small picture frame, and a sack of marbles. With a can opener, one side of the box was cut out and the glass inserted, through which the action could be studied. The power plant consisted of a straight plank 4 ft. long; and the auxiliary apparatus comprised a ruler and a watch with a second-hand. The general plan of this apparatus is shown in Fig. 1. The most interesting

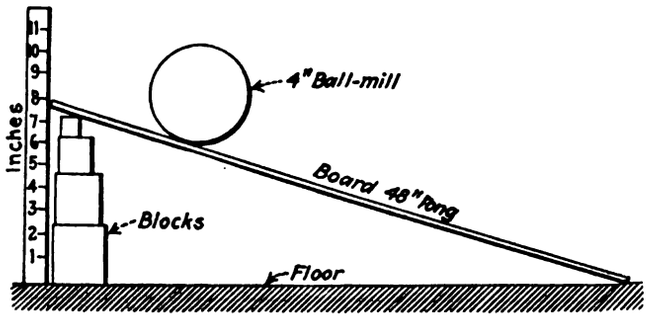

Fig. 1. Arrangement for Rotating Experimental Ball Mill.

thing about the device, and one which made quantitative measurements possible, was the fact that when the mill was partly loaded with balls, and the power plant was tilted up to make the balls roll over, cascade or throw over as in practical mills, the mill rolled down hill at a constant speed at which no variation in internal movements could be discerned. With the mill running down hill at a constant speed, the speed conditions of a practical mill are present, and it can easily be shown that with constant speed on a constant incline the power is constant, as in practical machines.

If the mill were empty, or were entirely filled with balls, or if the power plant were tipped up so that the speed increased to the extent of making the balls cling to the periphery, the mill rolled down hill at an accelerating speed, which of course was useless for power comparisons.

The matter of determining whether the speed was constant in such a simple apparatus may perhaps be questioned. Determinations were made by sound, character of the falling stream of balls at different points, and a little appreciation that certain laws of mechanics which will not be stated here would apply. The appearance of the falling stream of balls was obtained by taking a definite position opposite the path of the rolling cylinder and winking the eyes as it passed, getting about the same image one would get by a similar procedure opposite a mill rotating on a fixed axis.

Of course great accuracy and absolute assurance of constant speed could have been obtained by using a board or incline of considerable length for the power plant and with two or more observers, but the results came out in such a satisfactory manner that a more elaborate test seemed of little importance at the time.

Nothing new was found to add to that which has already been published with regard to the way in which the balls distribute themselves in falling. At slower speeds they rolled down over each other; at higher speeds they threw over, and at still higher speeds they clung to the rim, all of which is in accordance with the laws of mechanics.

In these tests it was usually necessary to start the mill with a shove. Record was kept of the height of one end of the 4-ft. plank, of the number of balls (marbles) in the mill, and the time taken to roll the four feet down the incline. To make the work easier, the end of the board was adjusted to make the time a fixed quantity, and five observations under each condition were made and averaged. The relative power was proportional to $\frac{hM}{t}$, in which;

h = height one end of plank was raised above other,

M = number of marbles in mill (all of same size), and

t = time in seconds to roll four feet at constant speed.

The critical speed for the rim of this mill (such that centrifugal force equals gravity) is about 2.2 revolutions per second, or about 131 r.p.m. Its circumference is 13 in.; it would travel down the four feet in 1.55 seconds at the critical speed of the rim, if at constant speed; as indicated before, this could not be determined experimentally. As the marbles had a diameter of about ½ in., the effective critical diameter was ½ in. less than the nominal diameter, so that the critical speed was somewhat nearer to one that would make it travel the four feet in almost two seconds.

Fig. 2 shows the relative power-load curves for this little mill, with times which approximate those of the speeds in practice. Consistent curves were obtained, and indicate interesting results, most of which, it must be admitted, have been determined by operators by testing large mills (at considerable expense, even if it were worth it, which I do not deny).

The power is maximum with a load between 60 and 75 per cent of the mill capacity, apparently depending slightly upon the speed at which the mill is run. Hardly enough data are available, however, to warrant the statement that at higher speeds somewhat heavier pebble loads may be carried for maximum capacity. With loads used in practice the power consumed is a direct function of the ball load. (Note how all the curves, if extended, apparently would pass through the zero of the

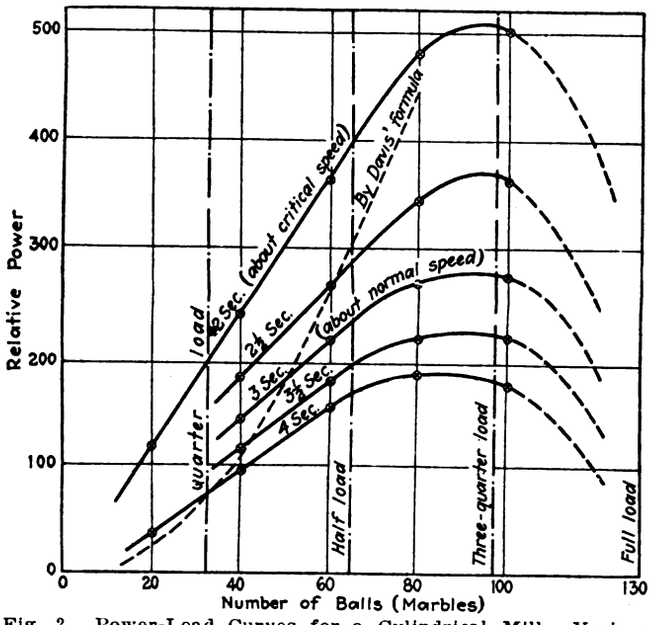

Fig. 2. Power-Load Curves for a Cylindrical Mill. Various Speeds. Bearing Friction Eliminated Dry Conditions. Ball Load Only.

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diagram). For a given mill, the power consumed increases a little more rapidly than directly proportional to the speed. Of course, as the pebbles begin to cling to the rim when the critical speed is exceeded, it is to be expected that the power consumption would decrease. The apparatus used could hardly determine that point, which, after all, is of minor importance, practically.

The data show that up to above half load, the power varies directly as the ball charge; in Davis' paper (Trans. A. I. M. E., Vol. 61) he derives some mathematical formulae for the power and shows that it increases much more rapidly than is proportional to the ball charge. One of the values in his table given below (Table I) is plotted dotted on Fig. 2. There appears to be a marked discrepancy.

TABLE I. HORSEPOWER REQUIRED PER FOOT OF MILL LENGTH.

Internal Diameter of Mill	Portion of Mill Volume Occupied by Charge					
Feet	0.1	0.2	0.3	0.4	0.5	0.6
1	0.0023	0.0099	0.022	0.042	0.065	0.093
2	0.0255	0.110	0.254	0.46	0.73	1.04
3	0.1087	0.463	1.07	1.94	3.07	4.38
4	0.288	1.24	2.87	5.22	8.25	11.78
5	0.64	2.72	6.29	11.43	18.07	25.74
6	1.20	5.16	11.88	21.47	34.14	48.69
7	2.06	8.85	20.43	37.06	58.61	83.53
8	3.26	14.12	32.54	59.08	93.46	133.32
9	4.96	21.32	49.09	89.31	141.24	201.33
10	7.13	30.81	71.06	129.00	204.07	291.10

For most efficient calculated speed, charge weighing 325 lbs. per cu. ft.

(The above is Table 16 in Davis' article referred to in the text.

Davis' formula for horsepower, which can best be understood from his paper already referred to, is of form hp.$=Wr^2/_3$ times the summation of A, B, and C, in which W is the weight of ball charge, r is the radius of the mill, and A, B, and C are constants depending upon functions of the ratios of diameters of the charges. Now, for a given ratio of ball charge to mill volume, W per foot of length varies as r^2, so that for constant ratio of load to mill volume, hp. $= r^7/_2$ times a constant.

About the time I made the ball-mill studies I also determined a formula for the horsepower of a ball mill, deriving it as follows:

Weight of balls per foot of length $= r^2$ times a constant; height of ball rise in mill $=$ r times a constant; speed of rotation of mill $=$ constant divided by $\sqrt{r}$.

This will check with Davis' derivation, as well as with a number of others. All other conditions being constant, the product of these three factors is a measure of the horsepower absorbed by the mill in raising the balls, thus:

hp. $= r^5/_2$ times a constant.

There is also another formula (?) for the horsepower of a ball mill, and it probably is the best of the lot; that of the manufacturers who have built a number of these mills. This formula is based on one big guess, plenty of grief, and a caution, or play-it-safe, factor. For the power consumption of commercial mills, where it can be measured with wattmeters by operators who are on the lookout for betterments and perhaps for come-backs at the manufacturer, the manufacturer's tables are likely to be close to the correct values. In Table II are given the power requirements of mills of various diameters, one foot long, by Davis' formula, by the five-halves formula, and the actual horsepowers from manufacturers' catalogs, each column being for the length of mill for which the most data were available. No apologies are offered to other manufacturers; the catalogs of the two named happened to be handiest, and they are about representative figures.

TABLE II. RELATIVE POWERS.

1	2	3	4	5	6	7
	Theoretical H.P. per Foot of Length		From Catalogs of Manufacturers—Horsepower			
Diam. of Mill in Feet	Davis' Formula	Five-Halves Formula	10 Ft. Long A. C. Pebble	5 Ft. Long A. C. Ball	5 Ft. Long A. C. Ball-Pebble	22 In. Long Hardinge Ball
1	1	1	..	...	..	...
2	11	5.7	..	...	..	...
3	47	15.6	..	15	15	...
4	126	32	19	...	26	...
5	278	56	28	50	45	30
6	524	88	43	80	71	50
7	900	129	63	110	..	75
8	1240	181	83	150	..	110
9	1870	243	..	...	..	...
10	2700	317	..	...	..	...

The difference between the two formulas are particularly noticeable in the table as the diameters increase. In the manufacturers' tables there is agreement in the upper part of columns 5 and 6; column 4 has values throughout a little over half the values in column 5. Column 7 appears to increase more rapidly with diameter than do the others, and this may be explained by the characteristics of the mill. For columns 4, 5, and 6, the formula has the form: hp. $= r^2$ to $^{2.25}$ times a constant. For column 7: hp $= r^{2.75}$ times a constant.

If, in using the horsepower values of columns 5 and 6, the diameter be reduced by six inches to get the true mill diameter, and this value used in the horsepower formula, the following will show the relation: hp. $= r^5$ times a constant. This checks with my calculated formula.

Here are several formulas for the horsepower of a ball mill, in which the effect of one factor varies to a considerable extent. The manufacturers' tables check more closely with my five-halves formula, and of course I am inclined to think, that it is approximately correct. But any one who runs through the mathematics whereby Davis derives his formula will believe it to be correct. Apparently there is no error, unless in assumptions as to the use of the energy inside the mill.

Davis bases his expression for horsepower upon the kinetic energy of the balls as they strike the side of the mill or the other pebbles at the end of their fall through the mill; I base mine upon the energy required to lift them to the point from which they start upon their free course through the mill. There cannot be much difference between these two assumptions. One method is a somewhat practical way of determining the power, and it checks with practical experiences; the other is a purely mathematical process, and looks logical throughout; but it does not check with experience, or at least it does not appear to do so.

It should be noted that in the experimental tests and in all the mathematical work outlined no consideration was given to the fact that in an operating mill there would be rock and probably water, in addition to the balls; however, there appears to be nothing in either the rock or water that would not conform to the same theory as outlined for the balls.

—By A. O. Gates. Written for Engineering & Mining Journal.

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BELT, GEAR AND CHAIN DRIVES FOR GRINDING MILLS

The mechanical arrangement for the driving of tube, ball, and rod mills is capable of a number of variations, no one of which can be termed universally the best. Thus, in a given mill which may be designed for an uncertain length of operating time, due to limited mine development or small ore reserves, the saving of first cost may be the vital element. A relatively cheap drive in first cost may suffice, although the maintenance costs may be high and safety considerations be sacrificed. On the other hand, in a mill designed for heavy continuous operation over a period of ten to fifteen years or longer, first cost becomes secondary and operation and maintenance of primary importance.

From a mechanical point of view, the driving of tube, ball, and rod mills is essentially alike. Each consists of a cylindrical or conical shell, lined with wearing plates which may or may not be ribbed. Usually the shell is supported on hollow trunnion bearings, or, in some mills, one bearing is a hollow trunnion and the other is constructed of a ring about the mill supported on rollers. The selection of drive is not greatly influenced by the trunnion or trunnion and ring support. The weight to be rotated is great and the speed attained is comparatively low.

Continuous Vibration Must Be Overcome by Drive Mechanism

The power required varies with the size and type of mill, but may reach a maximum of 215 H. P. in the larger ball mills and may be as low as 12½ H. P. for the smallest conical mill. Owing to the pebble or ball load constantly adjusting itself, the power curve consists of a series of maxima and minima, the difference between the peaks and depressions of the power curve depending upon the ball loading, the proportion of water, the condition of the lining and ribs, and the maintenance of the alignment of the mill. The result is a continuous vibration which must be overcome in the driving mechanism and which wears the bearings and other parts of the drive. There is no end thrust if the mill is perfectly aligned, but this is seldom continuously possible. This end thrust is, under common operating conditions, readily taken care of by the trunnion bearings.

The principal function of the drive is to reduce the speed of the motor to the low speed of the mill. Although this appears to be easy, it is surprising to note the variety of arrangements that are in current use. One of the first drives which I had an opportunity of studying was installed at the Butters' plant at Virginia City. This consisted of a motor and a belt drive of about 30 ft. centers to a countershaft which carried a friction clutch pulley and a bevel pinion which meshed with a bevel gear on the tube mill. The arrangement gave a lot of trouble, owing to the end thrust produced by the bevel gears. It admitted of a compact arrangement, but the belt was in a bad place for the operators. This form of drive has disappeared.

Horizontal Belt Drive

The simplest drive is a horizontal belt drive from the motor to a countershaft and a spur gear drive from the countershaft to the mill. Mechanically this arrangement is sufficient where a proper distance is allowed between pulley centers and the loose side of the belt is above. Driving several mills from an overhead lineshaft by belts to the mill countershaft is sometimes done, but it is necessary to use a belt tightener. This arrangement is in use at the mill of the Carson Hill Gold Mining Co., at Melones. Three conical mills are driven from an overhead lineshaft. The horizontal belt drive is objectionable, both on account of the mill space taken up and the dangerous position of the belt. The overhead drive with belt tightener does not take up floor space, and the belt is out of the way. Though objectionable mechanically, no special criticism of the arrangement from the metallurgical standpoint is warrantable.

Short Center Drive

The most recent belt drive is the short-center drive which is carried either horizontally or vertically from above the countershaft. Short-center belt drives with well-designed idler pulleys, such as the "Meeseco" and others of similar design, answer the purposes excellently, and many mills are driven in this manner. The pulley ratios are from 1 to 5, and higher ratios are practicable. The drive is noiseless and the slippage small. The floor space is greatly reduced as compared with the horizontal belt drive. The objection to the short-center belt drive is the increased cost of belt maintenance as compared with the horizontal belt drive. The rapid bending back and forth of the belt due to passing around the driving pulley and the idler undoubtedly wears out the belt much more rapidly than a drive where the belt bending is consistently in one direction. With well-proportioned and flexible belts the belt maintenance can be reduced to a minimum.

Advantages and Disadvantages of Belt Drives

An objection to all belt drives is the element of danger in their use. Also, when they slip off the pulleys they are difficult to replace. Being close to the mill they prevent ready access to all parts of it and are likely to be interfered with by mud, sand, and pulp which splashes and leaks from bolt holes occasionally. They are lower in first cost than any other drive and are therefore worthy of consideration for very small mills and low first cost plants. A flexible coupling is not required, but a friction-clutch pulley, in the absence of a belt tightener between the motor and countershaft, is usually necessary where standard squirrel-cage induction motors are used and is always necessary where synchronous motors (rarely employed) are used. The placing of a friction-clutch pulley on the countershaft is objectionable, as there is more or less spillage of sand and pulp about the mill, and some of it inevitably gets into the clutch, interfering with its operation. The result is dissatisfaction and sometimes damage to the electrical equipment follows.

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Silent Chain Drives

The silent chain drive has been adopted to some extent. The arrangement consists of a chain drive interposed between motor and countershaft and the driving of the mill from the countershaft by spur or herringbone gears. Neither flexible coupling nor clutch is required, but a clutch is necessary where motors of low starting torque are used. The arrangement is compact and admits of the motor being placed at some distance from the mill, where it will be protected from spillage. It is safe and efficient, and mechanically it works well. If unprotected by suitable housing, the chain is exposed to a certain amount of dust and dirt. The operating objections are the upkeep due to wear and the breakage of chain rods. When worn there is considerable back lash, but this can be compensated by the motor-base adjustment. The principal objections are its first cost and the expense for providing a suitable housing. By the use of a cast-iron spur gear for pinion and mill gear a saving in first cost is possible. On the whole, it is better than a belt drive if the additional first cost is allowable.

Gears

It is obvious that either spur or helical gears can be substituted for the chain drive. A double reduction of the motor speed by two sets of gears has certain mechanical advantages. It is more compact than the chain drive and can be readily housed. A flexible coupling is necessary between the motor and the pinion of the first gear. The maintenance cost is low and the first cost is lower than for a chain drive of equivalent speed ratio. Helical gears are to be preferred in place of spur gears, as the sliding contact secured reduces the effect of the vibration caused by the mill load and thus reduces the wear to a minimum. The preferable arrangement would be helical gears for the countershaft drive and a steel spur gear for the mill drive. A still lower first cost would be secured by a cast-iron gear for the mill drive.

Spur Gear Reducers

Various spur-gear reducers are upon the market. These consist of a self-contained unit admitting of a given reduction of speed between the motor and the countershaft. They are in effect the same as the gear drive just described. Some recent installations have adopted them. They are compact; the gears run in a bath of oil, and the upkeep and maintenance are low. As the speed reduction is large, they admit of the use of a high-speed motor, with consequent reduction in the motor cost. The speed-reduction unit is high in first cost and is therefore more suitable for large, long-lived plants. The arrangement protects the motor, is satisfactory from a metallurgical standpoint, and is more compact than the silent chain or ordinary double-gear drive. A flexible coupling between motor and speed reducer is required.

Single Gear Drive

The simplest drive from a mechanical standpoint is the single gear drive with countershaft direct connected to the motor through an interposed flexible coupling, an arrangement which brings the motor in close proximity to the mill and exposes it to spillage. The gears can be cheaply housed, however, and with reasonable care in operation there is comparatively little trouble from spillage. It is the most compact arrangement and may or may not be of lower first cost as compared with double-gear drive and speed-reducing gears.

Use of Herringbone Gear Gives Best Results

The double helical or herringbone gear drive is essential for satisfactory operation. With the herringbone gear a gear ratio of as high as 1 to 20 can be satisfactorily used. This calls for a countershaft speed of from 345 to 450 r. p. m., and therefore for a special low-speed motor. These motors can, however, be economically produced, although they are of higher cost than the standard induction motors. It is not economical to design small motors suitable for low speeds required by the single reduction drive, and this drive is therefore restricted to the larger sizes of ball and rod mills. Under careless operating conditions a comparatively high pinion wear is to be expected, on account of the exposed position of the gears, and this element should be given consideration, as the gears and pinion are expensive. Apart from this, the maintenance cost is low, and the method of driving has been favored in the large long-lived plants. Satisfaction is generally expressed by users of this arrangement.

Individual and Group Drives

Individual drives are most satisfactory for large mills and the larger plants. For the smaller mills and smaller plants, group drives are often used, although a complete analysis of each individual operation is essential to determine whether they are more economical in first cost and in operation. Against the saving in first cost of a single large motor as compared with the cost of individual smaller motors, the cost of the line shaft, its installation, and the power used in its operation must be placed. The cost for wiring and motor controls is greater with an individual than with a group drive. The individual drive has the advantage of a smaller reduction in mill capacity than the group drive in cases of lineshaft and motor troubles. The group drive with belts and belt tighteners works out fairly well, although it is not as safe in operation as other drives.

Motors

Motors used for ball, tube, and rod mills all require comparatively heavy starting torque. This is in excess of full-load torque. Motors for long tube mills require 1½ times full-load torque at starting, whereas motors for large-diameter ball and rod mills require twice the full-load torque. Squirrel-cage motors designed for particularly high starting torque can be used, but when permissible, wound-rotor motors are preferable. Wound-rotor motors are necessary for all large ball and rod mills.

Acknowledgment is made to Girard B. Rosenblatt and others for freely discussing their experience on this subject.

—By George J. Young, Western Editor, Engineering & Mining Journal-Press.

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THE DESIGN OF A BELT CONVEYOR

The nature of the work performed by conveyors makes it evident that two equipments are seldom exactly alike. There are, however, a few principles of design and operation applying to all conveyors, which, if carefully observed, will insure to the operator a long and satisfactory service.

To illustrate the design of a conveyor, we will assume a set of requirements and proceed with the successive steps involved in designing a conveyor to meet those requirements. For example, let us assume that we wish to carry crushed stone from our crusher a distance of 250 ft. to our bins which are located over a railroad track, making it necessary to elevate the material 70 ft. above the point where it is received from the crusher.

Preliminary Data

The first step is to list all the conditions which must be met by our proposed equipment. On studying our problem we find the following:

1—We must carry 2400 tons per day of 8 hours.

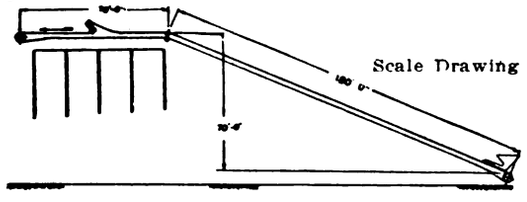
2—The capacity of the crusher is 375 tons per hour.

3—The maximum size piece is 5″ and 90% of the material is under that size.

4—It will be necessary to discharge the crushed stone into any one of our four bins at will.

5—There is ample room at the top of the farthest bin to locate a motor and driving gearing for the conveyor.

With these figures before us, we make a scale drawing, which shows, in outline, our proposed conveyor.



Width of Belt

Our next step is to ascertain the width of belt required. This is determined by:

a—The maximum size of piece to be carried.

b—The speed at which the belt should run when receiving the character of material which we are going to carry.

c—The tonnage to be carried.

a—In the second column of Table 1, "Capacities of Belt Conveyors," (See tables at end of this article) we note that a belt not less than 18″ wide is necessary to carry material whose maximum size pieces are 5″.

Even though the tonnage requirements indicate a narrower belt, the width given in the first column of Table 1 should be adhered to as a minimum, when carrying the size pieces indicated in the second column.

b—Table 3 gives the maximum advisable speed for crushed stone at 350 F.P.M. When the maximum size is as large as 5″, a speed of 300 F.P.M. is more desirable in that the belt will last longer.

Speed at Which the Belt Should Run

The speed at which a conveyor belt should be run is determined by:

1—The width of the belt.

2—The character of the material carried.

3—The amount of breakage allowable at the discharge.

4—The capacity desired.

Column 3 of Table 1 gives the maximum speed at which a given width of belt may be run. Table 3 gives the best speed corresponding to various materials. Picker Conveyors are run at 40 to 50 F.P.M. and Package Conveyors at 75 to 123 F.P.M.

To obtain the lowest tonnage cost, the speed should always be sufficiently low to keep the belt pretty well filled with the material being carried. At speeds under 150 F.P.M. the economy of a belt conveyor compared to other conveyors when handling bulk material is questionable.

Weight Per Cubic Foot of Material Carried

c—Our preliminary data shows that we must carry a total of 2,400 tons in 8 hours, or an average of 300 tons per hour. The capacity of the crusher, however, is 375 tons per hour. Evidently the feed onto the belt will be rather irregular and it will be necessary to use a belt wide enough to carry the full capacity of the crusher. Table 3 also tells us that crushed stone weighs approximately 110 lbs. per cubic foot. Now with these three figures before us, viz., 375 tons per hour, 300 F.P.M., and 110 lbs. per cubic foot, we consult Table 1. Here we find that a 30″ belt at a speed of 100 F.P.M. will carry 135 tons per hour of a material weighing 100 lbs. per cubic foot. At 300 F.P.M. it evidently will carry three times 135 or 405 tons per hour. Since this is but slightly over the 375 tons we wish to carry, we will use a 30″ belt.

The figures given in Table 1 as the capacities for the various widths of belt at a speed of 100 F.P.M. are based upon the assumption that the material is fed to the belt in a continuous stream. If the flow of material is not uniform it is evident that the belt must be large enough to handle the maximum quantity of material which may be fed to it at any one time. The various feeding devices used to insure a uniform flow of material to a belt are discussed further on in this article.

Selection of Proper Ply

The ply of a conveyor belt is determined by:

a—The width of belt.

b—The size, weight per cubic foot and abrasive character of the material fed to the belt.

c—The tension in the belt when it is being operated.

a—Table 4, which gives the usual ply used for belts of given widths, shows that a 30″ belt may be from 5 to 8 ply.

The relation between width and ply is based largely upon considerations of flexibility. A narrow belt must not be too stiff to trough properly and a wide belt must be heavy enough to prevent buckling. In the case of grain conveyors, lighter plies than those given in the tables may be used.

b—We will assume that the stone which we are going to carry is a hard, sharp material such as Trap Rock. For this condition an 8-ply belt will be advisable. The body of an 8-ply belt is needed to withstand the abrasive impact of a 5″ piece of Trap Rock.

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Ply Largely Determined by Material Carried

If the maximum size pieces in our example had been 2″ we could have used a 6-ply belt. If we had wished to carry run of mine coal, which is much lighter and softer than trap rock, we could have used a 6-ply, while 5-ply would have been sufficient to carry crushed coal, and 4-ply would be suitable for carrying grain.

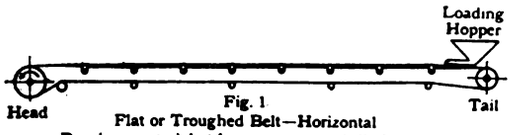

Fig. 1.
Flat or Troughed Belt—Horizontal
Receives material at hopper spout and discharges over head pulley

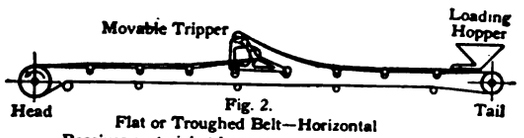

Fig. 2.
Flat or Troughed Belt—Horizontal
Receives material at hopper spout and discharges over tripper at various points.

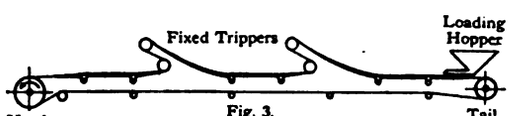

Fig. 3.
Flat or Troughed Belt—Horizontal
Receives material at hopper spout and discharges over trippers at fixed points and over head pulley.

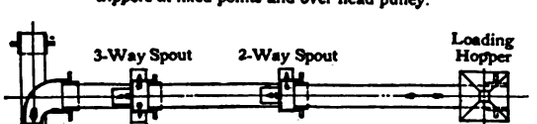

Fig. 4.
Method of Discharge from one conveyor to another running at right angles.

Ply Also Determined by the Tension in the Belt

c—To find the tension in the belt when it is running, it is necessary first to get the horsepower required to drive the conveyor. From Table 5 we find it requires 3.54 H.P. to run a 30″ conveyor empty at a speed of 300 F.P.M. This is for a length of 100 ft., and since ours is to be 250 ft., it requires $2.5 \times 3.54 = 8.85$ H.P. In order to distribute the stone at will into any one of the four bins, we will require a tripper. (See discussion of Trippers.) From the last column of Table 5 we find the use of a tripper will add 2.5 H.P., making 11.35. Finally we must add 8% because we wish to use an 8-ply belt (see foot note under Table 5), giving us $11.35 \times 1.08 = 12.25$ H.P. required to drive the conveyor empty.

From Table 6 we find that it requires 2.1 H.P. to convey 100 tons per hour a horizontal distance of 250 ft., or $3.75 \times 2.1 = 7.88$ H.P. to convey 375 tons the same distance.

From Table 8 we find that it requires 7.0 H.P. to elevate 100 tons per hour to a height of 70 ft. It will therefore require $3.75 \times 7.0 = 26.25$ H.P. to elevate 375 tons per hour the same height. Adding together these figures, we get:

H.P. required to operate empty conveyor	12.25
H.P. required to convey 375 tons per hour a distance of 150 ft...	7.88
H.P. required to elevate 375 tons per hour a height of 70 ft....	26.25
Total	46.38

The tension in the belt arising from the horse power transmitted to it by the driving pulley is found by the formula:

$$\frac{\text{Horse Power} \times 33{,}000}{\text{Speed in Feet Per Minute}} = \text{Effective Tension—F}$$

This is usually called "Effective Pull." The relation between ply and Effective Pull—F is expressed by the formula:

$$\frac{\text{H.P.} \times 33{,}000}{\text{F.P.M.} \times \text{Width} \times 20} = \text{Ply}$$

Substituting our values in this formula, we get:

$$\frac{46.38 \times 33{,}000}{300 \times 30 \times 20} = 8.5 \text{ ply}$$

The figure "20" in this formula is the value of F per inch of single ply when we have an arc of contact on the head pulley of 180°. By installing a snub at the head pulley we can increase the arc

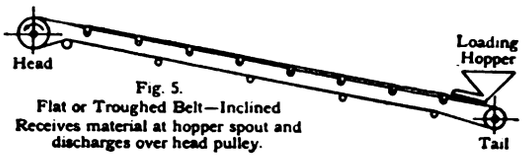

Fig. 5.
Flat or Troughed Belt—Inclined
Receives material at hopper spout and discharges over head pulley.

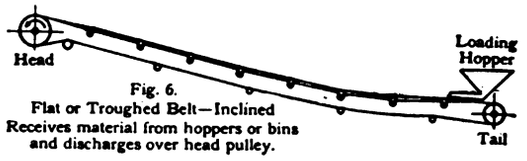

Fig. 6.
Flat or Troughed Belt—Inclined
Receives material from hoppers or bins and discharges over head pulley.

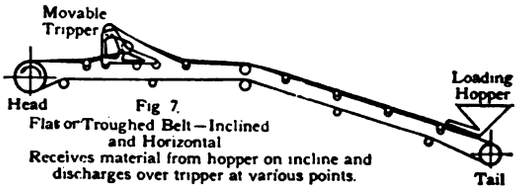

Fig 7.
Flat or Troughed Belt—Inclined and Horizontal
Receives material from hopper on incline and discharges over tripper at various points.

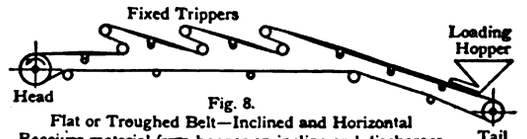

Fig. 8.
Flat or Troughed Belt—Inclined and Horizontal
Receives material from hopper on incline and discharges over trippers at fixed points and over head pulley.

of contact to 200°, which will increase F from 20 to 21.3. The formula then becomes:

$$\frac{46.38 \times 33{,}000}{300 \times 30 \times 21.3} = 8 \text{ ply}$$

Use of Snub Increases Effective Pull

The installation of a snub pulley enables us to use an 8-ply where otherwise it would have been necessary to use a 9-ply belt. The amount F is increased by increasing the arc of contact on the driving pulley, as given in Table 7.

The ply chosen must always be the greatest found necessary from a consideration of the three conditions, a, b and c, given above. For instance, if the tension on the belt should only require a 5-ply but the size and character of material should require an 8, then an 8-ply must be used.

The relation of width to ply given in Table 4 is based on the use of troughing idlers. If the belt is run flat, practically any ply can be used. If the

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troughing angle is greater than 20° a lighter belt than that indicated must be used.

Maximum Allowable Tension

Observations of a great many installations have shown that to insure an efficient operation the tension in a conveyor belt should not exceed 30 pounds per inch of width of single ply. This is the Maximum Tension-T in the belt as it approaches the driving pulley and is the sum of the Effective Pull-F and the Minimum Tension-T_1.

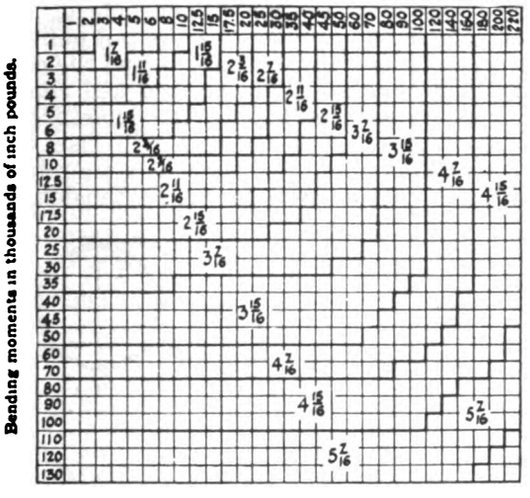
The Mininmum Tension-T_1 is the tension in the belt as it leaves the driving pulley. It is applied to the belt by the takeups to prevent the driving pulley from slipping and should never be greater than just enough to prevent such slipping.

The Effective Pull-F is the tension in the belt arising from the horse power transmitted to it by the driving pulley.

It has been demonstrated that under ordinary conditions with an arc of contact of 180° on the driving pulley (a half wrap around the pulley) a Maximum Tension-T of 30 pounds permits an Effective Pull F, of 20 pounds with a necessary Minimum Tension-T_1 of 10 pounds. This Effective Pull-F = 20 pounds is the value "20" used in the formula:

$$\frac{\text{H.P.} \times 33{,}000}{\text{F.P.M.} \times \text{Width} \times 20} = \text{Ply}$$

The Minimum Tension-T_1 necessary may be reduced and therefore the Effective Tension increased by lagging the driving pulley or by using a tandem drive. (See discussion on later page.)



Shafts for Combined Torsion and Bending. Tensile strength assumed, 62,500 lbs. Torsional moments in thousands of inch pounds.

Head and Tail Pulleys

Table 4 gives 42″ and 30″ respectively as the proper diameter for the head and tail pulleys of a 30″ × 8-ply conveyor. These pulleys should be crowned and should be 2″ wider than the belt.

Shafting

The chart gives diameters of shafts to be used when the horsepower, pulley diameters and R.P.M. are known, the bending moment and torsional moment being computed from these figures. From this chart we find our example requires a 4 1/16″ shaft for the 42″ head pulley and 3 1/16″ shaft for the 30″ tail pulley.

Large Head and Tail Pulleys Increase the Life of Belt

It is very important that the driving pulley should be of ample diameter. It is also important that the diameters should be ample in tail pulleys,

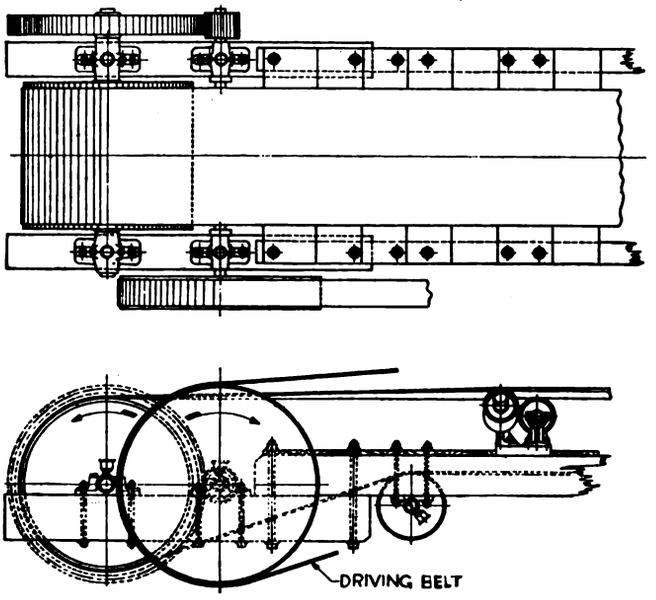


Fig. 2. Typical Arrangement of Head Pulley and Driving Machinery.

snub pulleys, automatic takeup pulleys, etc. When the diameters are too small, the fibres of the belt are unduly stressed and their resistance to the abrasive action of the material carried is greatly reduced.

Table 4 gives suitable diameters for head and tail pulleys for average conditions. When the tension on the belt is exceptionally heavy, larger pulleys should be used. The tail pulley should not be used as a driving pulley unless absolutely necessary.

Snub Pulleys

It frequently happens that the character of material carried requires only a light ply, but due either to the length of the conveyor or the height to which the material is elevated, the horse power required to drive it necessitates a heavier belt. In this case it is desirable to place a snub pulley near the driving pulley to increase the arc of contact, as we did in our example. This will increase the horse power which can be transmitted to the belt without increasing the tension on the belt. Increasing the arc of contact to 230° will increase the horse power which can be transmitted to the belt 15%, thus making it possible to use a 6-ply where otherwise a 7-ply would be required.

The diameter of the snub pulley should be three times the ply of the belt. Under no condition

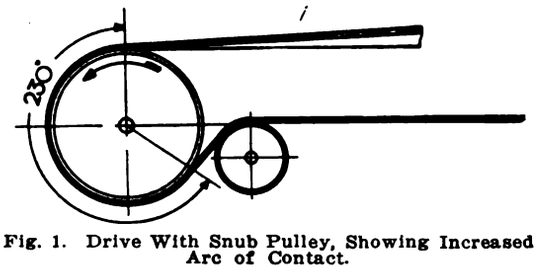


Fig. 1. Drive With Snub Pulley, Showing Increased Arc of Contact.

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should a return roller be used as a snub, either at the head or tail pulley. The disadvantage of a snub lies in the fact that the reverse bending of the belt causes the carrying surface to wear somewhat more rapidly. When sticky plastic material is carried, a scraper must be provided to keep the snub pulley clean.

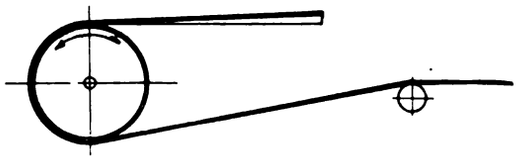

Fig. 5. Drive Without Snub.

Figure 2 gives a typical arrangement for a drive showing a desirable location for the driving shaft and the reduction gearing.

Tandem Drive

The "Tandem Drive" shown in detail in Figure 4 is the most effective drive for a conveyor, and should be used where the work is so heavy that a snub will not increase sufficiently the effective pull in proportion to the Maximum Tension-T on the belt.

A Tandem Drive can be located anywhere on the return side of the conveyor, but preferably near head pulley.

The two driving pulleys "A" and "B" are geared together. An arc of contact of approximately 230° may be obtained on "A" and 220° on "B."

From Table 7 we see that when the arc of contact is 230° the Effective Pull-F is 22.7 and the Minimum Tension T_1 is 7.3. This is the condition on pulley "A." When the arc is 220° and the Maximum Tension 30, the Effective Pull-F = 22.2 and the Minimum Tension-T_1 = 7.8. In the case of pulley "B," however, the Maximum T is 7.3, the same as the tension in the belt as it leaves pulley "A." From the relation $T:F:T_1 = 30:22.2:7.8$ we obtain the values of F = 5.3 and T_1 = 2 for the tensions on pulley "B." Adding together the Effective Pulls for the two pulleys, "A" and "B," we get 22.7 + 5.3 = 28 pounds, which is the Effective Pull for the drive.

By using the Tandem Drive, we would reduce the tension in the return side of the belt from 10

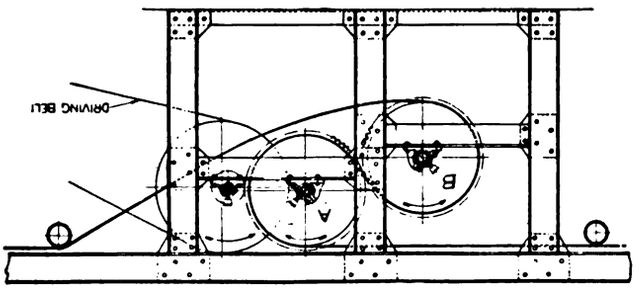

Fig. 4. Typical Arrangement of Tandem Drive.

to 2 pounds and increase the Effective Pull from 20 to 28, a gain of 40%, without increasing the Maximum Tension above the allowable figure, 30 pounds.

Lagging the Driving Pulley

Lagging the driving pulley with rubber belting will increase the possible effective pull about 15% when the material carried is moist. It is especially advisable to rubber lag pulley "B" in a tandem drive. The rubber lagging acts as a cushion for material which may adhere to the carrying face of the belt and otherwise would be forced into the belt by the hard face of an iron pulley.

Takeups

The 500-foot belt in our example would require an adjustable takeup with a 36" movement. An adjustable takeup makes it possible to keep the belt at the proper tension.

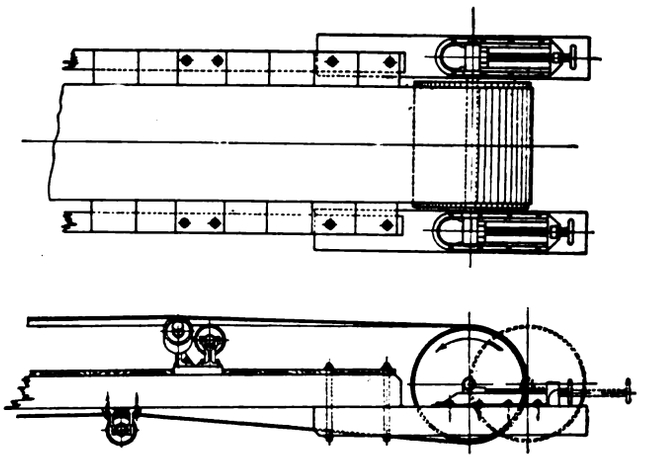

Fig. 6. Typical Arrangement of Tail Machinery and Framing.

Automatic Takeup

The movement of a takeup should be about 1% of the length of the conveyor. Figure 6 shows a standard screw takeup installed at the tail pulley. Figure 7 shows an automatic takeup which can be installed anywhere on the return side of the belt between the driving pulley and the tail pulley. This latter type is especially desirable when the conveyor is very long or when there are marked changes in the atmospheric humidity or the moisture in the material carried. The weights will rise and fall with the change in length of the belt, thereby maintaining a constant predetermined tension in the

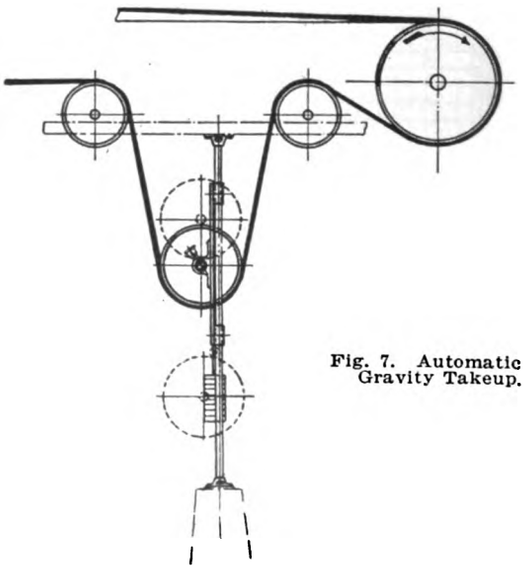

Fig. 7. Automatic or Gravity Takeup.

belt. The weight used should be the minimum required to prevent the driving pulley from slipping. The diameters of the pulleys used in an automatic takeup should be three times the number of plies in the belt. An automatic takeup in

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conjunction with a tandem drive is a very desirable equipment.

Spacing of Idlers

From columns 7 and 8 of Table 4 we find the carrying rollers should be located at intervals of 2′ 6″ and the return rollers at intervals of 10′ when a 30″ x 8-ply belt is used.

As may be seen from the table the spacing of carrying rolls is determined by the weight of the material carried and the width of the belt. At the feeding point the spacing should be about one-half that given in the table. The object of this is to prevent spillage and to provide an extra support for the belt where it receives the impact from the material being fed it.

Material must never be fed directly over a roller unless it is very fine. The slight "spring" of the belt when suspended between rollers is required to prevent excessive abrasion from heavy pieces.

A return roller should never be placed close to a driving pulley to increase the arc of contact. When this is necessary a snub pulley must be installed.

Alignment of Rollers, Etc.

Accurate alignment of the head and tail pulleys, carrying rollers, return rollers, and snub pulleys is of the utmost importance. A snub pulley out of line may easily cause the belt to catch on the side of the equipment and destroy itself.

Guide Idlers

Guide idlers should be placed about 12 ft. from the tail pulley and 12 ft. from the head pulley. In between these positions they should be spaced about 30 to 40 ft. The use of guide idlers is more or less in the nature of a necessary evil. If the belt rubs against them very hard it is proof that some part of the equipment is out of line. The disadvantage in the use of idlers lies in the fact that it is easier for the workmen to install two or three guide idlers, in order to make the belt run true than to re-align the equipment, with the result that the belt rubs against the idlers very hard and wears away until it is too narrow to carry the load.

Character of Feed Is Very Important

The most important single element in the conveyor is the feed. The life of a belt can easily be cut in half by the use of an incorrect feeding device or by failure to keep in order a device which originally was correct.

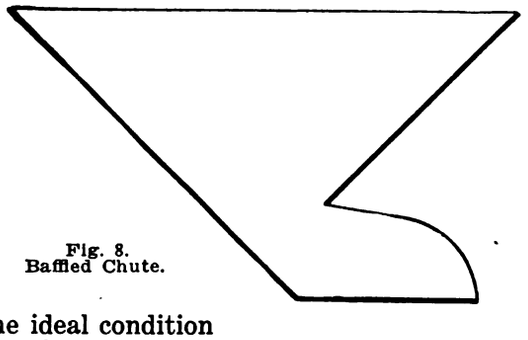
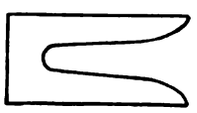


Fig. 8. Baffled Chute.



Plan of Bottom Plate.

The ideal condition is when the material is fed to the center of the belt with a velocity equal to that of the belt and in the direction of its travel. Figure 8 shows a very good baffled chute used very widely in handling ore.

When the material contains a quantity of fines a grating should be provided, as shown in Figure 9, which allows the fines to drop through to the belt, thereby furnishing a cushioning bed which will take the impact of the larger pieces and thus protect the belt. A grating cannot be used with material which is moist or contains much earthy matter.

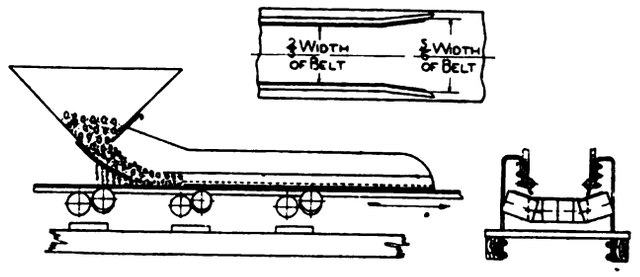


Fig. 9. Fines Forming Cushion for Coarse Material. Typical Arrangement of Skirt Boards.

Mechanical Feeders

The maximum capacity of a belt can only be utilized by feeding the material to it at a uniform rate. Any one of the mechanical feeders shown in Figures 10, 11 and 12 is used to accomplish this result, the type of feeder used depending upon the characteristics of the material handled and its volume.

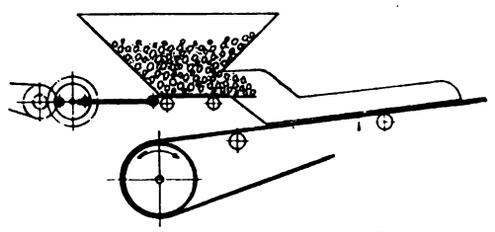


Fig. 10. Reciprocating Plate Feeder.

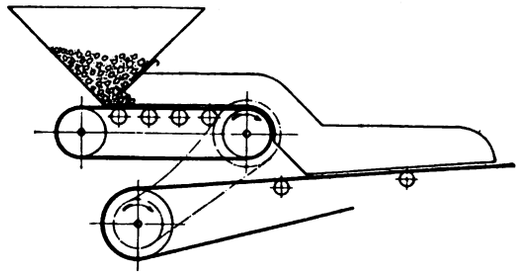


Fig. 11. Belt Feeder.

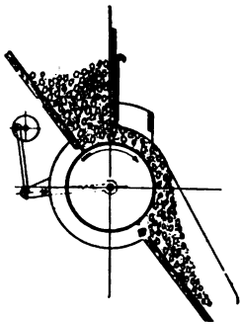


Fig. 12. Rotary Drum Feeder.

The reciprocating plate feeder and the belt or apron feeders are especially well adapted to handle large size material.

The belt feeder is merely a short belt conveyor placed under the hopper opening and feeding to the main conveyor. It runs over flat rollers spaced very close together and generally is operated by sprocket and chain from the tail shaft of the main conveyor.

The Apron Feeder is similar to the Belt Feeder with the exception that it is constructed of metal

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throughout. The apron is built up from a series of corrugated steel slats mounted on two strands of roller chain and runs over sprockets instead of pulleys.

The Rotary Drum Feeder consists of a cast-iron drum or cylinder revolving at the hopper opening. The rotation of the drum allows a definite quantity of the material to escape at each revolution. Frequently the periphery of the drum is cast with rather deep longitudinal corrugations which tend to drag the material out in successive measured quantities. The Rotary Drum Feeder is adapted to feeding small size material.

Table 9 can be used as a guide in determining the thickness of plate to use in designing a chute.

When the pieces are large and the material heavy, thicker plates must be used where the impact occurs.

Skirt boards should be provided at the discharge point of the chute, as shown in Figure 9. They should extend from 4 to 7 ft. along the length of the belt. A piece of belting should be bolted to the lower edge of the skirt board. The wooden portion should be from 1¼″ to 1¾″ in thickness, from 6″ to 8″ in height, and from 1½″ to 2″ above the surface of the belt. The distance between the guide boards should not exceed ⅔ of the width of the belt. The skirt boards should flare out at the discharge end to allow the material to spread out gradually upon the belt.

Discharging Devices

The great majority of belt conveyors discharge over the head pulley. Frequently, however, it is necessary to discharge the material at some point between the head and tail pulley, for instance, to fill one of a series of bins. This operation is taken care of by a fixed or movable tripper, shown in outline in Figure 13.

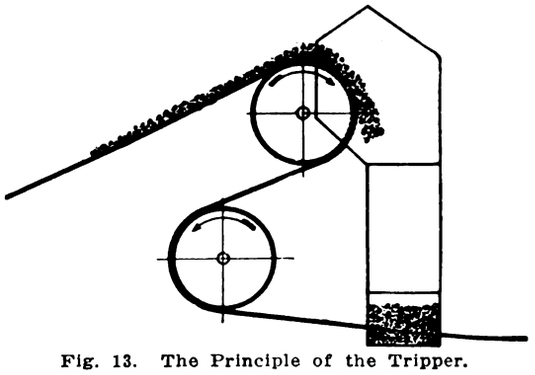

Fig. 13. The Principle of the Tripper.

Trippers

The fixed tripper consists of two pulleys, one located above and ahead of the other. The belt passes over the upper pulley and then over the lower one, the material discharging into a chute which carries it to either or both sides of the conveyor.

The movable or traveling tripper is similar in operation to the fixed tripper. The single difference is that it is mounted with its discharge chute on a four-wheeled frame. This frame travels along standard T rails, and will discharge the material evenly along its length of travel. It is provided with a rail clamp, so that it may be secured at any point and thus function as a fixed tripper.

Movable trippers are of three general types:

1. Hand propelled trippers which are moved from place to place by hand.

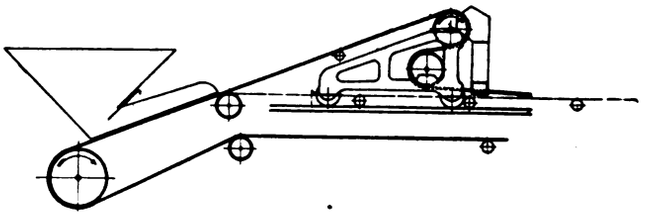

Fig. 14. Arrangement of Tail End to Allow Maximum Extension of Tripper Travel.

2. Self propelled trippers which are moved by means of a mechanism which utilizes power from the moving conveyor belt.

3. Automatic trippers which are actuated by the motion of the conveyor belt and which travel back and forth over a predetermined path without attention.

Owing to the fact that the conveyor belt must bend around the tripper pulleys in an "S" shaped path, the pulleys must not be too small. Suitable diameters are given in Table 10.

The longest possible travel of a tripper is obtained by deflecting the tail end of the conveyors (see Figure 14) so that the angle of the belt is approximately the same as the angle which the belt assumes as it passes to the tripper. This deflection also prevents the belt being lifted from the rollers near the feeding chute and causing it to foul the chute. Where the belt is deflected the carrying roller should be a flat roller and of generous diameter.

Scraper Boards

When a flat conveyor is used, the material may be removed from the belt at any point by means of a scraper board set diagonally across the belt as shown in Figure 15. This method should not be used if the material is abrasive and has sharp cutting edges.

The scraper board is usually provided with a narrow strip of belt attached to its lower edge to prevent the board from actually coming into contact with the belt. The material drops onto a sloping shed or chute extending between the carrying and return side of the belt, which prevents any ma-

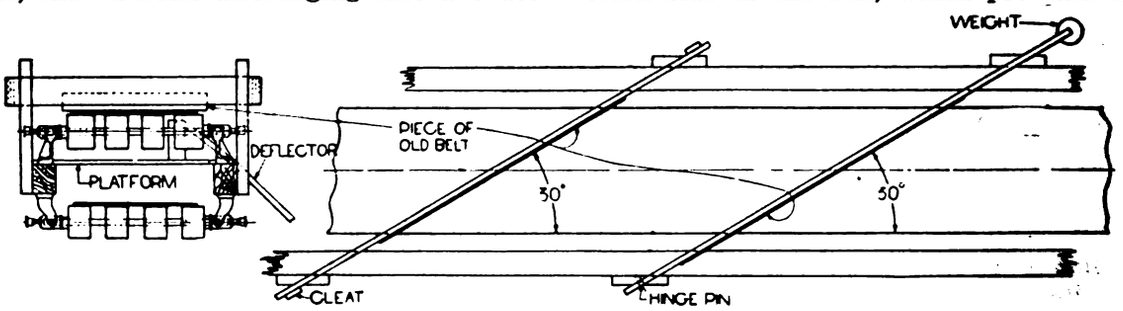

Fig. 15. Common Methods of Scraper Board Arrangement.

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terial lodging on the return side of belt and being crushed between the belt and pulley.

Inclined Conveyors

As in the case of our example conveyor, it is frequently necessary for a conveyor belt to run up an incline. The maximum allowable angle of inclination largely depends upon the physical characteristics of the material and the way it is fed to the belt. A given material can be carried at a much greater angle when fed uniformly than when fed intermittently. In general, fine materials, and coarse materials containing considerable fines, can be carried at a greater angle than sized coarse materials. A fine material when wet may be carried at a greater angle than when dry.

When the feed is uniform, it is good practice to use an angle of 18° for crushed stone, ore, run of mine coal, and sized coke; 20° for fine coal mixed with large lumps; 22° for fine coal; 24° for wet sand containing loam; and 25° to 30° for packages, like a sack of meal resting lengthwise with the belt. Some materials cannot be carried at an angle greater than 15°.

When a conveyor is inclined during the first part of its length and then runs horizontally, it is necessary to use a flat roller at the point where the angularity changes, unless the change is made very gradually.

Protection From the Weather

Rain, snow, ice and direct sunlight in summer will cause any belt to deteriorate. A conveyor located outside of a building should be well protected by a substantial housing, provided with ample windows and lights to aid in inspection.

Protection for Return Side of the Belt

A light wooden decking should extend the full length of the conveyor between the two runs of the belt. This will prevent material from spilling on to the return side and punching holes through the belt as it passes around the tail pulley or collecting on the tail pulley if the material is sticky.

The supporting framework to which the conveyor rollers, head pulley and tail pulley are fastened should be made of heavy material and thoroughly braced. To run satisfactorily a conveyor equipment must be kept in proper alignment. This cannot be done unless the supporting framework is rigid. It is very poor economy to endeavor to save money on a framework which is to carry an expensive conveyor belt when the belt can very easily be destroyed if the equipment gets out of line.

Joining the Belt, Inspection, Etc.

Great care should be used when making a joint in a conveyor belt to see that the belt is cut exactly square at the ends. A Talcott, Crescent, or Alligator Fastener should be used, and each rivet or prong, as the case may be, carefully hammered down, so that each hook is securely fastened. The directions always sent with the fasteners should be very carefully observed.

A daily inspection of a conveyor equipment is a very paying investment. The feeding chute, hopper, or mechanical feeder, as the case may be, must be kept in perfect repair so that it functions as it was originally intended to. A carefully designed feeding chute like Figure 8, in which the bottom plate has been worn away, can easily double the tonnage cost of a conveyor.

No part of a feeding device should ever be allowed to come in actual contact with the conveyor belt.

When screw takeups are used, they must be frequently adjusted to keep the tension on the belt only sufficient to make it drive. When the belt is too tight, it is difficult to make it track properly and the abrasive action of the material fed becomes more severe. This is illustrated by the homely comparison to the taut string which is cut more easily than when loose.

Broken rollers should be replaced immediately. An accumulation of spilled material on either side of the carrying rollers should be immediately removed. Scrapers provided for the purpose of keeping the snub pulleys clean must be kept in repair so that they do their work.

The lubrication of each and every conveyor roller, snub pulley, etc., must be systematically attended to.

A belt conveyor properly designed, carefully installed, and kept in perfect order, is a wonderfully efficient mechanical device. If it is not properly cared for, it quickly becomes a very expensive one.

TABLE 1. CAPACITIES OF BELT CONVEYORS.

Belt Width in Inches	Max. Size of Pieces in Inches	Max. Belt Speed in Feet per Minute	Capacity at Belt Speed of 100 Feet Per Minute								
			Flat Rollers			Troughed Rollers 15°			Troughed Rollers 20°		
			Cubic Feet per Hour	Tons per Hour W=50	Tons per Hour W=100	Cubic Feet per Hour	Tons per Hour W=50	Tons per Hour W=100	Cubic Feet per Hour	Tons per Hour W=50	Tons per Hour W=100
12	2	250	216	5.45	10.9	390	9.5	19	....	.....	...
14	3	300	294	7.4	14.8	530	13.	26	....	.....	...
16	4	300	384	9.6	19.2	690	17.	34	....	.....	...
18	5	350	486	12.2	24.4	870	22.	44	970	24.5	49
20	6	350	600	15.0	30.0	...	....	..	1200	30.0	60
22	7	400	726	18.1	36.2	...	....	..	1450	36.5	73
24	8	400	864	21.6	43.2	...	....	..	1730	43.	86
30	12	450	1350	33.8	67.6	...	....	..	2700	67.5	135
36	14	500	1944	48.6	97.2	...	....	..	3900	97.5	195
42	18	550	2646	66.2	132.4	...	....	..	5300	13.2	264
48	20	600	3456	86.4	172.8	...	....	..	6900	17.25	345

TABLE 2. GRAIN CONVEYORS.

Belt Width in Inches	Speeds and Capacities		
	Best Speeds in Feet per Minute	Bushels per Hour at Best Speeds	Bushels per Hour at 100 Feet per Minute
18	450	2490	553
20	450	3080	684
22	600	5020	836
24	600	5920	986
30	650	10010	1540
36	700	15500	2215
42	750	22620	3015
48	800	31520	3940

TABLE 3. WEIGHTS OF MATERIALS AND ADVISABLE BELT SPEED.

Kind of Material	Average Weight Lbs. per Cubic Foot	Advisable Belt Speed F. P. M.
Ashes	40	300
Cement	90	300
Coal (Lump)	55	250
Coal (Fine)	50	400
Coke	30	250
Earth	100–120	350
Gravel	100–120	350
Lime	55	300
Copper Ore	125	300
Sand	110	350
Stone (Coarse)	100	250
Stone (Crushed)	110	350

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TABLE 4. BELT CONVEYOR DATA.

Belt Width in Inches	Usual Ply	Head Pulley Diameter Inches	Tail Pulley Diameter Inches	Spacing of Carrying Rollers			Spacing Return Rollers
				Material 50 Lbs. Cu. Ft.	Material 75 Lbs. Cu. Ft.	Material 100 Lbs. Cu. Ft.	
12	4	16-18	12	5′-0″	5′-0″	5′-0″	12′-0″
14	4-5	18-20	12-14	5′-0″	5′-0″	5′-0″	12′-0″
16	4-5	18-20	12-14	5′-0″	5′-0″	5′-0″	12′-0″
18	4-5	18-24	12-18	5′-0″	4′-9″	4′-6″	12′-0″
20	4-5	20-24	14-20	4′-9″	4′-6″	4′-6″	12′-0″
22	5-6	24-30	16-20	4′-6″	4′-6″	4′-3″	12′-0″
24	5-6	24-30	16-24	4′-6″	4′-6″	4′-3″	10′-0″
30	5-8	30-42	18-30	4′-0″	4′-0″	3′-6″	10′-0″
36	6-8	36-42	20-36	3′-9″	3′-9″	3′-6″	10′-0″
42	6-8	36-54	24-42	3′-6″	3′-6″	3′-3″	8′-0″
48	6-10	48-60	30-42	3′-6″	3′-3″	3′-0″	8′-0″

TABLE 5. HORSE POWER REQUIRED TO RUN BELT CONVEYORS EMPTY 100 FEET CENTER TO CENTER WITH 6-PLY BELT

Width of Belt Inches	Speed in Feet Per Minute											H. P. to Add for Each Tripper
	100	150	200	250	300	350	400	450	500	550	600	
12	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	.5
14	.44	.66	.88	1.10	1.32	1.54	1.76	1.98	2.20	2.42	2.64	.5
16	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	.8
18	.60	.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	1.0
20	.67	1.01	1.34	1.67	2.01	2.34	2.68	3.01	3.35	3.68	4.02	1.3
22	.72	1.08	1.44	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32	1.5
24	.85	1.27	1.70	2.12	2.55	2.97	3.40	3.82	4.25	4.67	5.10	1.8
30	1.18	1.77	2.36	2.95	3.54	4.13	4.72	5.31	5.90	6.49	7.08	2.5
36	1.52	2.28	3.04	3.80	4.56	5.32	6.08	6.84	7.60	8.36	9.12	3.3
42	1.82	2.73	3.64	4.55	5.46	6.37	7.28	8.19	9.10	10.01	10.92	4.0
48	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54	10.60	11.66	12.72	5.0

For 4-ply belts deduct 8% from value in table. For 8-ply belts add 8% to value in table.

TABLE 6. HORSE POWER REQUIRED TO CONVEY MATERIAL HORIZONTALLY.

Center to Center Distance in Ft.	Tons Per Hour																			
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
50	..	..	.1	.1	.1	.1	.2	.2	.2	.2	.2	.3	.3	.3	.3	.3	.4	.4	.4	.4
75	..	.1	.1	.1	.2	.2	.2	.3	.3	.3	.4	.4	.4	.4	.5	.5	.5	.6	.6	.6
100	..	.1	.1	.2	.2	.3	.3	.3	.4	.4	.5	.5	.5	.6	.6	.7	.7	.8	.8	.8
150	.1	.1	.2	.3	.3	.4	.4	.5	.6	.6	.7	.8	.8	.9	.9	1.0	1.1	1.1	1.2	1.3
200	.1	.2	.3	.3	.4	.5	.6	.7	.8	.8	.9	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.7
250	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
300	.1	.3	.4	.5	.6	.8	.9	1.0	1.1	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.4	2.5
400	.2	.3	.5	.7	.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.3	2.5	2.7	2.8	3.0	3.2	3.3
500	.2	.4	.6	.8	1.0	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.8	4.0	4.2

TABLE 7. VALUES OF T^1 AND F FOR VARIOUS ARCS OF CONTACT AND COEFFICIENTS OF FRICTION WHEN T = 30 LBS.

Arc of Contact in Degrees	f = .25 Poor Conditions Dirty C. I. or Steel Pulleys			f = .35 Normal Conditions Clean C. I. or Steel Pulleys		
	T	T^1	F	T	T^1	F
90	30	20.25	9.75	30	17.3	12.7
100	30	19.35	10.65	30	16.3	13.7
110	30	18.50	11.50	30	15.3	14.7
120	30	17.75	12.25	30	14.35	15.65
130	30	17.05	12.95	30	13.6	16.4
140	30	16.3	13.7	30	12.75	17.25
150	30	15.65	14.35	30	11.9	18.1
160	30	14.9	15.1	30	11.25	18.75
170	30	14.3	15.7	30	10.65	19.35
180	30	13.7	16.3	30	10.	20.
190	30	13.15	16.85	30	9.3	20.70
200	30	12.55	17.45	30	8.7	21.3
210	30	12.	18.	30	8.3	21.7
220	30	11.5	18.5	30	7.8	22.2
230	30	11.	19.	30	7.3	22.7
240	30	10.5	19.5	30	6.9	23.1
250	30	10.	20.	30	6.55	23.45
260	30	9.6	20.4	30	6.2	23.8
270	30	9.2	20.8	30	5.8	24.2

T = Tension in belt as it approaches the driving pulley.
T^1 = Tension in belt as it leaves the driving pulley.
F = T — T^1 = Effective Pull.
Maximum Tension — T = 30 lbs. for ordinary conditions.

TABLE 8. HORSE POWER REQUIRED TO ELEVATE MATERIAL.

Height Material is Raised in Feet	Tons Per Hour																			
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
5	..	..	..	.1	.1	.2	.2	.2	.3	.3	.3	.3	.3	.4	.4	.4	.4	.5	.5	.5
10	..	.1	.2	.2	.3	.3	.4	.4	.5	.5	.6	.6	.7	.7	.8	.8	.9	.9	1.0	1.0
15	..	.2	.2	.3	.4	.5	.5	.6	.7	.8	.8	.9	1.0	1.1	1.1	1.2	1.3	1.4	1.4	1.5
20	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
25	.1	.3	.4	.5	.6	.8	.9	1.0	1.1	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.3	2.4	2.5
30	.2	.3	.5	.6	.8	.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	3.0
40	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
50	.3	.5	.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.5	4.8	5.0
60	.3	.6	.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0
70	.4	.7	1.1	1.4	1.8	2.1	2.5	2.8	3.2	3.5	3.9	4.2	4.6	4.9	5.3	5.6	6.0	6.3	6.7	7.0
80	.4	.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0
90	.5	.9	1.4	1.8	2.3	2.7	3.2	3.6	4.1	4.5	5.0	5.4	5.9	6.3	6.8	7.2	7.7	8.1	8.6	9.0
100	.5	.10	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0

TABLE 9. GAUGE FOR STEEL CHUTES.

Kind of Material	12″ to 20″ Belt	24″ to 30″ Belt	36″ to 48″ Belt
Light Materials such as Grains	14 Gauge	12 Gauge	10 Gauge
Medium Material such as Coal	10 Gauge	1/8″	1/8″ Side 1/4″ Bottom
Heavy Material such as Sand and Stone	1/8″	1/8″ Side 1/4″ Bottom	1/4″ Side 3/8″ Bottom

TABLE 10. DIAMETER OF TRIPPER PULLEYS.

Ply of Belt	Minimum Advisable	Desirable Diameter
4	10 inches	12 inches
5	12 inches	15 inches
6	16 inches	20 inches
8	24 inches	30 inches

—Main Beltnig Co.

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GENERAL NOTES ON THE USE AND CARE OF BELT CONVEYORS

A satisfactory conveying system may be described as one that moves the maximum amount of material with the minimum of strain on the equipment. Although this statement applies equally to all types of conveying machinery, it is particularly true of belt conveyors, where "long distance" conveying is particularly desirable.

Limitations of Use

With a few exceptions, belt conveyors can always be used to advantage in conveying material where the inclination is not so great as to require a vertical elevator. These exceptions are:

1—When material is hot or excessively wet.

2—With relatively short centers and heavy loads.

3—When frequent intermediate discharges are required, even though belt discharges and trippers are within certain limits very satisfactory.

Advantages

The advantages claimed for belt conveyors are as follows:

1—Large Capacity: Dependent upon speed of belt, which is often as high as 600 feet per minute for the wider belts and 200 or 300 feet per minute with narrower belts.

2—Power Requirements: Much less than so-called "scraper conveyors."

3—Small Maintenance Charges: No complicated machinery. Cost of upkeep low if reasonable attention is given the belt.

4—Accessibility: All parts easily inspected.

5—Protection of Material: No breakage or reduction in size of material.

6—Flexibility in Loading and Discharge: Loaded by spouts, mechanical feeders or by hand. Unloaded by trippers or over the end.

7—Light Weight: Lightest type considering capacity. This is advantageous from construction viewpoint.

8—Freedom from Shutdown: No packing or choking.

Capacity, size and speed of belts are interdependent, although the size or width may be influenced by the size of the material where the quantity conveyed is small and the pieces large. Where the quantity is great the capacity fixes the width. In either case the speed should be as slow as possible. A slow speed belt may be loaded more deeply than one at high speed, and when a narrow belt is run much above the advisable speed the load thins out and the capacity does not increase as the speed.

The maximum length of the different widths of conveyors is determined by the fiber stress in the belt and is therefore closely related to the load and speed. Naturally level conveyors may be built longer than those lifting material. Conveyors 1000 ft. from center to center handling 400 tons per hour have been most satisfactorily operated.

Another important factor in the design of conveyors at high speed, handling large quantities, is the flow of material in the chutes. A 36 in. conveyor handling 750 tons of coal per hour with a belt speed of 750 ft. per minute under a 10,000 ton pocket could not be loaded from a single chute, because it was not possible for the coal to attain a speed of 750 ft. per minute in the chute. It was necessary, therefore, in order to obtain a full load to open seven gates, each placing a layer of coal on the belt until the desired load was obtained. During a test this belt carried about 800 tons per hour.

Flat and Troughed Conveyors

The conveyor belt is usually troughed to obtain increased capacity. Belts running flat, however, will successfully handle packages, bags, etc., and in many cases bulk material. Flat belts are not adapted to handle material of large size, especially if the lumps are round and likely to roll, or if the belt runs up too steep an incline.

One of the principal advantages of flat belt conveyors is that the conveyor rollers, which consist of a series of pulleys placed close together and mounted on the same shaft, are not injurious to the belt. For that reason any ply can be used, to suit the nature of the material and width of feed. The only factor which limits the number of plies is the size of the head and tail pulleys, or the size of the tripper pulleys, if a tripper is used.

Plies recommended are:

12″ and 14″ wide	3 or 4-ply
16″, 18″ and 20″ wide	4 or 5-ply
22″, 24″ and 26″ wide	5 or 6-ply
28″ and 30″ wide	5, 6 or 7-ply
32″, 34″ and 36″ wide	6, 7 or 8-ply
42″ and 48″ wide	7, 8 or 9-ply
54″ and 60″ wide	8 or 9-ply

Flat belts have the additional advantage that material of a non-abrasive nature may be discharged at intervals without the use of a tripper by simply using a load scraper placed diagonally across the belt. Flat belts are capable of handling about half the capacity of troughed belts of the same width. This decreased capacity is largely offset by the increased life of the belt and by the reduced first cost of the machinery.

Flexibility

A belt should conform to trough by its own weight, to get guiding action of central horizontal part of idler. If too stiff, it will ride the inclined side rolls, run out of line, and bear hard against

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guide rolls, injuring edges; if too flexible, it will crease longitudinally in angle of trough, starting a separation of the plies at these points; it will also tend to flatten or lose its troughed form between idlers.

The life of the belt is very much prolonged by using pulleys of ample size; small pulleys are very hard on a thick belt and on the protecting cover, tending to separate the plies and crack the cover. The diameter (in inches) of the driving pulley should not be less than five times the number of plies, and for more important conveyors of considerable capacity or length, a diameter of eight times the number of plies is advisable.

The following table gives the minimum size of driving pulleys which should be used on the various widths of belt dependent on the number of plies:

MINIMUM SIZE OF DRIVING PULLEYS

Width of Belt Inches	Diameter of Driving Pulley Inches	Width of Belt Inches	Diameter of Driving Pulley Inches
12	16 to 18	26	24 to 30
14	16 to 18	28	24 to 30
16	20 to 24	30	30 to 36
18	20 to 24	32	30 to 36
20	20 to 24	34	30 to 42
22	20 to 30	36	30 to 48
24	24 to 30		

Tension

The working tension in a belt should not exceed 24 pounds per inch per ply, which is approximately 1/16 of the breaking strain of a good belt; 36 pounds per inch per ply is the extreme outside limit, and this should be used only for temporary installations.

Extra Covering

For permanent installations and ordinary conditions, and in cases where the belt is exposed to moisture, an extra protecting cover on the carrying side should be used, varying in thickness according to the character and the quantity of the material handled. From 1/16″ to 1/8″ is sufficient to resist mere abrasion during the life of the belt; more than 1/8″ need only be used where the material is unusually heavy or coarsely broken with sharp cutting edges.

Inclination

Troughed belt conveyors will handle material successfully at an inclination, but this is limited to an average of 20 degrees. With some materials that flow very readily this must be reduced to 18 degrees. Such materials as foundry sand, for example, which do not flow readily, may be handled at an inclination of 25 degrees. The conveying capacity of inclined conveyors is reduced from 5 to 10% as compared with horizontal conveyors.

Life of Belts

This is a question usually asked, and one in which the purchaser is vitally interested. As can be readily appreciated from all of the foregoing notes, it is dependent on many factors.

The causes of wear in any conveyor belt can be divided into two general classes:

1—The wear due to the abrasive or other destructive action of the material carried.

2—The wear due to the movement of the belt over the conveyor rollers.

In the first case the main factors depend:

I. On the number of places material is fed to the belt, because wear of the carrying surface is caused by impact.

II. On the way in which the material is fed, because this impact is greatest when material is not fed in the direction of the travel and at the same speed.

III. On the carrying of a full load, because only a small portion of the material carried then ever touches the belt, and there is the least wear for a given capacity.

IV. On the length of the belt, because the longer it is, the less frequently any portion comes under the feed chutes, and the less frequently it bends under tension over the pulleys.

V. On the grade of the belt, on its cover, and the thickness of the cover.

VI. On the abrasive character of the material handled.

In a theoretically perfect equipment the wear due to the first class named would be the total wear. In practice, however, it frequently happens that, owing to their incorrect design, the rollers themselves are the principal cause of the belt's failure.

In the average conveyor the belt, which is the most costly part of the installation, is worn out more by the rollers over which it runs than by the material carried.

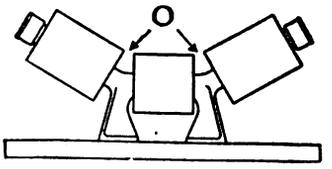
The faults in roller design which produce this result are of five general kinds:

I. Immoderately Steep Troughing Angles: The usual troughing roller bends the belt through an angle of at least 25°, and in some cases as much as 45°. The certain result of this excessive bending is longitudinal cracking of the belt along the line at which the bend occurs. This, rather than legitimate wear, is the cause of the premature failure of many belts.

Excessive troughing puts under strain those fibres of the belt which must withstand the abrasive wear of the load carried and like any other material under strain, their life is greatly reduced.

Under no circumstances should rollers be used whose angle of trough is greater than 20°. If greater capacity is needed, a wider belt should be used. The increased cost of belting incurred when the belt is troughed 25° to 35° far exceeds the advantage of the gain in capacity.

II. The Presence of a Groove or Opening Just at the Troughing Point: The weight of the load carried forces the belt down into the openings



at "O" in the sketch, until it wears on the edges of the pulleys, and ultimately crack longitudinally.

III. Rigid Bearings: Any conveyor equipment will eventually get more or less out of line because

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of the hard use to which it is put. When the bearings are cast together with their supports, any change in the relative position of the members of the supporting framework makes the pulley-shaft bind. Pulleys which do not turn wear out the belt.

IV. The Attempt to Trough Too Great a Portion of the Belt Width: Even if the angle of trough is only 20° the attempt to bend up a large portion of the belt, so that the sides are raised very high above the center, is injurious to the belt. This is because the strain caused by bending them occurs near the center of the belt, where the greatest abrasive action is encountered.

V. Imperfect Lubrication: Belt conveyors are subject to hard usage; they are often exposed to atmospheric conditions and are quite frequently operated in very dusty surroundings. Hence the type of lubrication employed must efficiently combat these conditions; otherwise plenty of trouble will result, as any practical man knows.

The above are some of the more important conditions affecting the life of a belt, and it will be seen that some of these can be very readily controlled, while others can not.

Discharging Devices

Most conveyors receive material at one end or at various points in their length and discharge over the head pulley. When necessary to discharge at points between the ends, either fixed or movable trippers are used. The fixed tripper consists of two pulleys, one located above and ahead of the other. The belt passes over the upper pulley, then over the lower in such manner that the material is discharged from the belt into a chute which will carry it to the side of the conveyor.

When fine size material is being conveyed, these trippers may be made automatic, so that the stream of material will be deflected into the first bin until filled. The material will then fill up in the chutes, flow back on itself to the belt and be carried to the second tripper, and so on until all bins are filled. Should material be drawn from any bin, the stream will immediately be deflected until the bin is again filled and then pass on. The writer has used eight such trippers on a single conveyor.

The movable or traveling tripper is similar to the fixed tripper in form and operation. The two pulleys and chute are mounted on a frame supported on four flanged wheels. A pair of rails extending the length of the conveyor provides track for the machine and enables it to discharge material at any point in the length of its travel. The tripper is usually provided with some clamping device to secure it to the rails when discharging in a fixed position.

Trippers are moved in the following ways: The hand propelled type is moved by crank with pinion and gear to the truck wheels. Others use a wire rope with winch located at one end of the conveyor. The self-propelled tripper is driven by power taken from the conveyor belt, through suitable gearing to the truck wheels.

A lever on one side properly connected with the driving mechanism controls the direction of travel of the machine. This lever engages adjustable stops located on the rails at the desired limits of discharge and the tripper will travel between these stops, automatically reversing at each end. A lever is provided which will throw this moving mechanism out of gear, allowing the machine to discha ge in a fixed position.

Cleaning Belts

When the material handled is damp it is advisable to provide some mechanism to clean the belt after it passes over the discharge pulley; otherwise a small quantity will be carried back by the return belt. For this purpose, rotary brushes, made of various fibers, are used. These brushes revolve at a high speed, sweeping the material into the chutes. They are driven from the conveyor belts and are provided with means of adjustment for the wear of the fiber.

When very sticky material, such as clay, is being conveyed, a strong water spray is used to clean the belts. An air blast has been used to clean belts, but the large volume and high pressure required makes this method expensive.

Chutes and Feeders

One of the most important features of belt conveyor design is that of providing chutes which will properly load the material onto the belt. Mine run ore may be fed to a belt conveyor so that it will not injure the belt, but with improperly designed chutes the highest grade belt may be ruined in a few weeks when it should last for years.

It is impossible to lay down any rules for the design of chutes. It is a subject requiring a careful study of local conditions and a complete knowledge of the materials handled and of the manner in which they will move in chutes under various conditions.

The material should always be delivered to the belt in the direction of the belt travel and as nearly as possible at the same speed, so that it will go from chute to belt with no shock or jar. When feeding a conveyor from bulk, for example, from storage bin, some type of automatic feeder should be used to insure an even and continuous feed to the belt. This is particularly important when handling unsized material. Should a simple gate be used, it must be set for the large lumps, the result being a rush of fine material after the lump has passed. If a feeder is so driven that it will start and stop with the conveyor it feeds, it will generally save the expense of an attendant at the loading end and prove more satisfactory.

The writer favors the shaking feeder consisting of an inclined pan set under the bin opening at such an angle that it stops the flow when stationary. When given a reciprocating motion by crank and connecting rod the material is moved along the pan to the belt. By varying the length of stroke and inclination of the pan the amount of material delivered may be absolutely regulated.

Power Required

The power required to drive a belt conveyor depends on a great variety of conditions, such as the spacing of idlers, type of drive, thickness of belt, etc.

In figuring the power required, it is important to remember that the belt should be run no faster than is required to carry the desired load. If for any reason it is necessary to increase the speed, the figure taken for the load should be increased in proportion and the power figured accordingly. In other words, the power should always be fig-

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ured for the full capacity at the chosen speed, as follows:

C = Power constant from table.
T = Load in tons per hour.
L = Length of conveyor between centers in feet.
H = Vertical height in feet that material is lifted.
S = Belt speed in feet per minute.
B = Width of belt in inches.

For level conveyors,

$$H.P. = \frac{C \times T \times L}{1000}$$

For incline conveyors

$$H.P. = \frac{C \times T \times L}{1000} + \frac{T \times H}{1000}$$

Add for each movable or fixed tripper horse power in column 3 of table.

Add 20 per cent. to horse power for each conveyor under 50 ft. in length.

Add 10 per cent. to horse power for each conveyor between 50 ft. and 100 ft. in length.

The above figures do not include gear friction, should the conveyor be driven by gears.

POWER REQUIRED FOR GIVEN LOAD

	1	2	3	4	5
Width of Belt	C for material weighing from 25 lb. to 75 lb. per cu. ft.	C for material weighing from 75 lb. to 125 lb. per cut. ft.	H. P. required for each movable or fixed tripper	Minimum plies of belt	Maximum plies of belt
12	.234	.147	½	3	4
14	.226	.143	½	3	4
16	.220	.140	¾	4	5
18	.209	.138	1	4	5
20	.205	.136	1¼	4	6
22	.199	.133	1½	5	6
24	.195	.131	1¾	5	7
26	.187	.127	2	5	7
28	.175	.121	2¼	5	8
30	.167	.117	2½	6	8
32	.163	.115	2¾	6	9
34	.161	.114	3	6	10
36	.157	.112	3¼	6	10

With the load and the size of material known, choose from the capacity table the proper width of belt and proper speed. The above formulae give the horse power required for the conveyor when handling the given load at the proper speed. With the horse power and the speed known, the stress in the belt should be figured by the following formula to find the proper number of plies. Stress in belt in pounds per inch of width $= \frac{h.p. \times 33,000}{S \times B}$
With this value known, the number of plies may be determined, using 20 lb. per inch per ply as the maximum. The columns 4 and 5 of the preceding table give the maximum and minimum advisable plies of the different widths of belt. Belts between these limits will trough properly and will be stiff enough to support the load. The maximum number of plies determines the maximum length for each width of conveyor.

Compiled from data furnished by Link Belt Co., Robins Conveyor Co. and Main Belting Co.

CAPACITY CYLINDRICAL BALL MILLS

Capacities are for medium hard quartz and in closed circuit with classifier or screen.

Size of Mill in Ft. Dia. x Lgth.	Tons per 24 Hours 2" to 48 Mesh	Tons per 24 Hours 2" to 14 Mesh	H. P. Required to Run	H. P. of Motor Recommended	R. P. M. of Mill	Ball Charge in Pounds
3x3	20	30	10	15	40	1,200
3x5	30	40	15	25	40	2,000
4x4	40	75	25	40	32½	3,000
5x4	60	120	40	60	28	5,000
5x5	75	150	50	75	28	6,500
6x4	120	210	60	85	24	9,000
6x5	150	260	80	100	24	11,000
6x6	190	320	100	125	24	13,500
7x5	225	375	110	125	20	18,000
7x6	275	450	135	150	20	23,000
8x5	320	500	150	175	18	25,000
8x6	385	600	180	200	18	30,000

From Catalog The Allis-Chalmers Mfg. Co.

CAPACITY CONICAL BALL MILLS

Capacities given are for medium hard quartz ore and in closed circuit with classifiers or screens.

Size of Mill, Dia. Length Ft. In.	Tons per 24 Hrs. 2" to 20 Mesh	H. P. Required to Run	H. P. Motor Recommended	R.P.M. of Mill	Ball Charge in Pounds
3x8	8	5	7½	35	1,000
4½x16	40	18	25	33	4,500
5x22	60	30	40	29	7,500
6x22	150	50	60	26	12,000
7x22	200	75	100	24	20,000
7x36	250	85	125	24	27,000
8x22	300	110	150	22	30,000
8x36	400	150	200	22	34,000
8x48	550	200	250	22	42,000

From Catalog The Hardinge Co.

CAPACITY CONICAL PEBBLE MILLS

Capacities given are for medium hard quartz ore and in closed circuit with classifiers or screens.

Size of Mill, Dia. Length Ft. In.	Tons per 24 Hrs. ¼" Feed to 28 Mesh	H. P. Required to Run	H. P. Motor Recommended	R.P.M. of Mill	Pebble Charge in Pounds
3x8	6	3	5	36	300
4½x16	20	8	12½	32	2,500
6x22	45	18	25	28	4,500
6x30	55	21	30	28	4,800
6x48	70	27	35	28	5,500
8x22	100	40	50	24	10,000
8x30	125	48	60	24	11,000
8x36	140	55	60	24	12,000

From Catalog The Hardinge Co.

CAPACITY CYLINDRICAL PEBBLE MILLS (TUBE MILLS)

Capacities are for medium hard quartz and in closed circuit with classifiers or screens.

(Intermediate lengths furnished every 2 feet; power, capacity, and pebble charge proportional.)

Size of Mill in Feet, Dia. x Length	Tons per 24 Hrs. 8 Mesh to 95%-100M	H. P. Required to Run	H. P. Motor Recommended	R.P.M. of Mill	Pebble Charge in Pounds
4x8	25	15	20	32	5,000
4x12	29	23	30	32	7,500
4x16	38	30	40	32	10,000
4x20	40	38	50	32	12,500
5x8	42	22	40	28	7,800
5x12	50	33	50	28	11,800
5x16	59	44	50	28	15,700
5x22	75	61	75	28	21,500
6x8	55	34	50	24	11,300
6x12	71	52	75	24	17,000
6x16	90	70	100	24	22,600
6x22	118	97	125	24	30,200
7x10	85	63	75	20	19,200
7x16	120	100	125	20	30,800
8x10	112	83	100	18	25,100
8x16	186	134	150	18	40,200

From Catalog Allis-Chalmers Co.

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BELT ELEVATORS FOR ORE AND WATER*

The notes in this article are an outline of the writer's experience with these very essential, though at times troublesome, machines in wet concentrating mills. What he has to say, especially as to wear and tear, may not strike with much force those fortunate millmen whose experience with this type of machine has been confined to elevators of low lift and of a capacity ample to raise a moderate burden of fine material. Such an elevator gives little trouble.

A Comparison

The writer at one time had in charge an elevator raising about 100 tons of ore in 24 hours, ranging in size from 4 mm. to 0 mm., to a hight of 43 ft., and the belt and buckets, after being in continual service for four years, deducting occasional periods when the mill was shut down for repairs, and not exceeding 48 hours, finally fell into the boot.

It was almost a forgotten machine in the mill. Evidences of much wear were lacking, the belt giving way from the deterioration of the rubber and the breaking of the threads of the plies from much passing around the head pulley. In the same mill was an elevator which every 24 hours raised about 700 tons of ore ranging in size from 60 mm. to 0 mm., and was a constant source of trouble. Its belt could not be depended upon to last longer than six months.

These two elevators serve admirably for comparing the factor of wear due to size and quantity of material, the height, speed, quantity of water raised, etc., being very nearly the same in both. Data for these two elevators as well as for the other elevators mentioned in this article will be found in a table at the end of this article.

Elevator belts are generally of what is known as special belting, a belt with an extra heavy coating of rubber. The net prices for the various widths and plies of the highest grade with the heaviest cover, at Denver, are shown in the following table:

ELEVATOR BELTING—PRICES PER LINEAR FOOT—1921

Width Inches	Ply					
	4	5	6	7	8	10
12	0.96	1.20	1.44	1.68	1.92	2.40
13	1.05	1.31	1.58	1.83	2.10	2.62
14	1.14	1.42	1.72	1.98	2.28	2.84
15	1.23	1.53	1.84	2.15	2.46	3.06
16	1.32	1.64	1.98	2.30	2.64	3.28
18	1.49	1.86	2.24	2.61	2.99	3.72
20	1.67	2.09	2.51	2.92	3.34	4.17

Rubber deteriorates rather rapidly with age and for this reason an elevator belt is made up by the manufacturer upon receipt of an order for it. Belts subjected to extra hard wear cannot be depended upon to last longer than six months, and as three months will usually elapse between the receipt of the order by the manufacturer and the arrival of the belt at the mill, it is a good plan to order a second belt immediately upon the arrival of the first one. Not infrequently, owing to the exasperating delays in receiving elevator belts, the millman is forced to keep in use a belt that should properly be on the scrap heap.

On receiving a new belt the rubber should be carefully examined. The millman will prefer a tough, whitish rubber offering considerable resistance to compression by the thumb. A piece of the rubber, after being stretched, should promptly assume its original shape. Any shortness or permanent distortion of the rubber, especially when accompanied by softness and a brownish black color, should be looked upon as evidence of unsoundness. The extra coating of rubber on the back or pulley side of the belt is of very little service in belts subjected to hard wear. Particles of ore lodging between the boot pulley and the belt are driven into the rubber and soon loosen it. The writer has frequently had to remove the entire back coating from belts which had been in service only a few weeks.

Power Required

It is possible to arrive at a very close approximation of the power required to drive elevators under normal conditions, but it must be remembered that elevators are frequently subjected to sudden and severe shocks, and this factor must be considered in estimating the power required to drive them.

The ordinary millwright usually pays no attention to the question of the power required to drive an elevator other than to assign an arbitrary horsepower, usually ten. Calculations will be entered upon here to determine the horsepower required to drive the elevator shown in Figs. 1, 2, and 3, the details of which will be found in column 4 in the table at the end of the article. This is an elevator of extraordinary size. The writer has frequently stood over the hood and watched this elevator discharge. The buckets came up in a steady line and were filled with ore and water to within 1 in. of the top. There was a heavy overflow from the boot and the aim was to raise as much water as possible with the tailings for the purpose of sluicing. The buckets were 8x18 in. of the "AA" form and held 9.4 liters when filled to within 1 in. of the top.

The total length of the belt was 126.33 ft. and the number of buckets with 20-in. spacing was 75; 350 tons of rock were raised in 24 hours. This weight multiplied by 56.91 ft., the vertical lift, gives the number of foot-pounds of work per day, or 27664.5 foot-pounds per minute. The bucket holds, when filled to within 1 in. of the top, 573.62 cu. in.

The elevator delivers 486.11 lb. of ore per minute and the number of buckets passing any point per minute is 297; consequently the ore per bucket is 1.64 lb. and occupies 16.43 cu. in., on the assump-

*By Edward S. Wiard, in Eng. and Min. Journal.

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tion that its specific gravity is 2.8. Deducting this volume from 573.62 cu. in., the capacity of the bucket, we have 559.09 cu. in. of water which weighs 20.13 lb. This weight multiplied by 297 will give the weight of water raised per minute and this multiplied by the lift will give the theoretical number of foot-pounds required to raise the water.

	Foot-pounds (per min.)	Horsepower
Water	340,242.69	10.31
Ore	27,664.5	0.84
Total	367,907.19	11.15

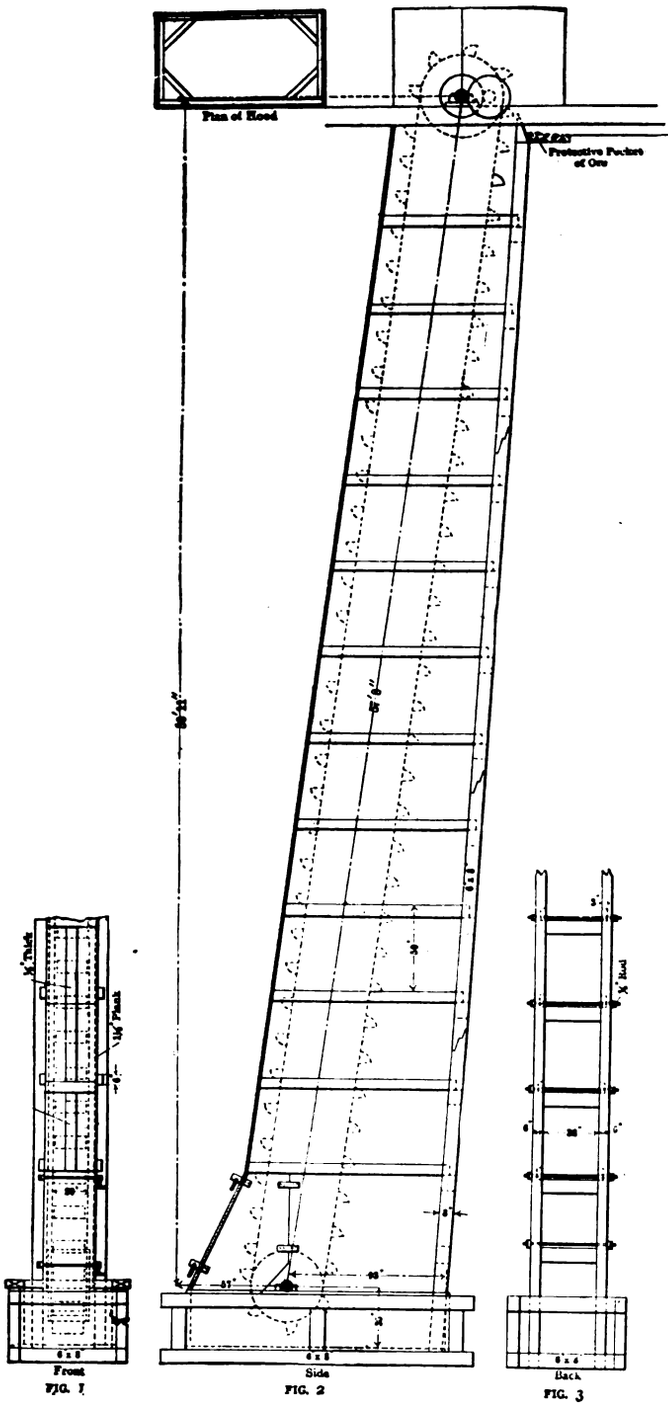

FIG. 1 FIG. 2 FIG. 3

Front, Back and Side Elevations of the Elevator Described.

The water elevated is 716 gal. per minute or 1,031,040 gal. per 24 hours. Assuming that of the total power required to drive the elevator, 30 to 33 per cent. is used in shaft friction, the normal horsepower required would be about 15.

Tension of Belt

The strength of rubber belting is about 4000 lb. per sq. in. A 20-in., 10-ply belt will therefore break under a load of about 40,000 lb. The tension in the belt due to raising the ore and water will be, $T = \frac{\text{h. p.} \times 33{,}000}{V}$, where V = velocity in feet per minute, and h. p. = theoretical horsepower. This, in the elevator under consideration, will amount to 741.5 lb. Neglecting the inclination of the elevator as it is so nearly vertical, we must add one-half the total weight of buckets and belt and, say, 300 lb. for the tightening tension applied when the belt is bolted together, giving as a total maximum tension at the head pulley, 2341.5 lb. The belt weighed 1100 lb., the buckets 20 lb. apiece. This gives a safety factory of 17.1 when the belt is new. For this particular elevator this factor seemed to be sufficiently large.

Boots and Housings

Metal housings, boots and hoods are seldom used in ore mills. They do not adapt themselves to the wooden construction in vogue in western mills, are difficult to repair and their first cost is great. Certainly the forms of housing and boots used in the grain trade, and confidently proposed for use in ore mills, would not answer for elevating wet ore. This is especially true if the elevator is given a slope, for in that case the back must be vertical or nearly so in order to prevent undue wear of the housing. This will necessitate a long boot.

The boot should be wider than the casing so as to allow the bearings to be placed entirely outside the housing proper. The boot should be of such a size that sufficient ore can accumulate around the sides and bottom to protect the lining from the wash of the elevator. In an elevator having an overflow, a roomy boot will help to check the flow of material from the entering spout. All the rock will then be elevated and as much as possible of the water. A boot pulley 24 to 30 in. in diameter is sufficiently large for most elevators.

The rim and the rim end of the spokes should be cast extra thick since these are the places of greatest wear. The boot boxes should be covered if possible as an additional precaution against the entrance of grit. It is a custom among millwrights to place the boots of elevators below floors in the darkest corner to be found, whereas, if possible, they should be exposed to the light on all four sides. Necessarily when in a dark and disagreeable situation, the boot bearings are neglected. A well designed and accessible elevator can be kept in as well ordered a condition as any machine about the mill.

Although he has never seen it tried, the writer believes that four bonnet-shaped collars, together with the placing of the bearings outside the housing, would amply protect them. In many mills the entrance of water between the shaft and the babbitt of the boot boxes is so great that it is impossible to keep the journals and bearings greased, in fact no attempt is made to do it. With a bonnet collar the coat of grease which would accumulate between it and the box would materially assist in keeping out sand.

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Vertical and Inclined Elevators

The necessity for using tightening devices is a serious objection to vertical elevators; they must also be run faster in order to discharge with the same facility as an inclined elevator. It is impossible to keep these tightening devices in good working condition. A hinged boot of the size needed for wet elevators would be a very cumbersome affair to handle, but is very serviceable for elevators of small size, which have a tendency to stall, or for making repairs. With a stationary boot provided with a number of plugs of ample size, it is a matter of only a few minutes' work, aided by the water from a high-pressure hose, to free the pulley and buckets. If possible a line of hose attached to a high-pressure cock should be provided near all elevators that are subject to being stalled.

Elevators fed from the side should be provided with heavy plates of iron on the bottom to receive the impact of the ore. If a Blake form of crusher is used, the old worn plates will serve admirably for this purpose.

An elevator fed from the front, at first glance, appears to be far more efficient than one fed from the side; but, as has been pointed out elsewhere, a certain amount of ore must necessarily be thrown from the buckets which has to be scooped up from the boot. Elevators fed from the front cause less wear on the boot pulley, less wear on the corners of the buckets and less attack on the back of the belt due to ore being forced in between the pulley and the belt. The writer is inclined to advocate a front feed for fine material; but for coarse material, especially if the elevator is over-driven, the wear on the front side of the belt would more than offset the advantages enumerated. It is also necessary for material fed from the front to enter high, causing a loss of head room and making it rather difficult to protect the bearing from grit.

Improved Housings

The housing shown in Figs. 1, 2, and 3 is the result of the experience of many millwrights and millmen. The back timbers are the only ones that enter the boot and they are at the rear end, out of the way. The doors which swing back above the bearing are the only parts of the elevator that are

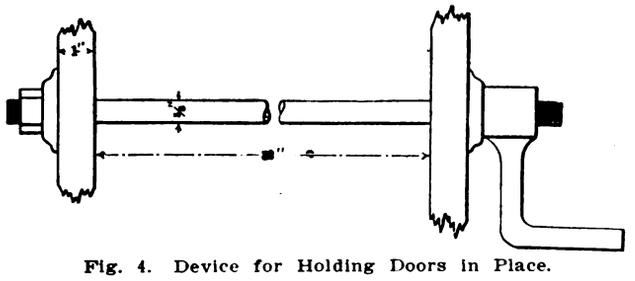

Fig. 4. Device for Holding Doors in Place.

ordinarily necessary to open in making repairs, but if any further opening is desired, only boards need be removed, no framed timbers being in the way. The whole front of the elevator from top to bottom can readily be removed. Fig. 1 shows that it consists of 8-ft. sections screwed to the ends of the casing. The lowermost section of the front and the two doors are held securely together when the elevator is closed, by the device shown. Each door contains two lugs firmly secured at the top and the bottom. These are bored to receive the threaded rods shown. When the elevator is closed the rods are run through the lugs and plain nuts are screwed on the left-hand end. The right-hand nuts, to which have been welded handles, are then screwed on and the doors are tightened to place. The boards of the casing proper are 1½ in. thick and were grooved for tongues at the sawmill. Wherever possible the elevator casing was secured to the timbers comprising the mill frame. No foot support was found necessary for the side and front of the casing. The back timbers at the top are framed into the heavy timbers supporting the upper bearings, the weight of the upper pulley, and the belt and buckets. These timbers in turn rest directly on the timbers of the mill frame. The diameter of the upper pulley in this elevator was 48 in. and the speed of the belt about 500 ft. per minute.

Diameter of Pulley and Speed

Nothing is to be gained in gripping power by increasing the diameter of the head pulley or widening the belt and the face of the pulley, the load remaining the same. But, as will be shown later, the tendency to break the plies of the belt increases as the diameter of the pulley is reduced. Since the centrifugal force would diminish as the diameter of the pulley was increased, the belt speed remaining the same, there would finally arrive a point in increasing the diameter of the head pulley, where the buckets would not discharge cleanly into the receiver.

The writer's rule for the minimum speed at which the belt should be run is the diameter of the head pulley in feet multiplied by one hundred. This would give as a safe speed for a 36-in. pulley 300 ft. per minute, for a 48-in. pulley 400 ft. per minute, etc. A much higher velocity than the safe speed is allowable. Elevators with head pulleys of ordinary diameters, 30 to 40 in., have been run with belt speeds as high as 650 ft. per minute on dry material.

By increasing the diameter of the head pulley we are enabled to increase the belt speed and hence the capacity of the elevator, and reduce the belt tension without unduly increasing the centrifugal force. With curved buckets and so mobile a substance as ore and water, there is no danger of material being carried back to the boot by the adhesion of the ore to the face of the bucket from centrifugal force. The effect of increasing the speed of the belt, as the writer has observed, has been to cause the ore to rise in a higher crested curve and to land farther back in the receiver pocket.

The elevator illustrated in this article threw the ore and water in a beautifully curved stream to the far or discharge end of the receiver pocket. The wear on the receiver iron was small and no coarse ore fell back into the boot. On placing the hand into the stream of ore descending into the receiver, one finds that there is a gradation from water, at the top of the stream, to the coarsest ore nearer the buckets. This seems to indicate that an elevator raising coarse material should run faster than one raising fine. The elevator illustrated in the article raised tailings from 40 mm. to 0 mm. in diameter. The writer advocates adding 100 ft. per minute to the minimum-speed rule given above.

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Receivers, Pulleys and Buckets

As to the placing of the receiver iron no rule would be complete without taking into account the speed of the belt, the diameter of the upper pulley, and the size and weight of the ore particles. The writer fails to see what advantage is to be gained by placing the edge of the receiver iron much below the center line of the pulley. If the elevator discharges properly, 12 to 16 in. should be ample. Discharge from a vertical elevator into the receiver cannot take place after the bucket is completely reversed. The receiver iron is placed on a slant to prevent the accumulation of ore at the bucket end of the pocket.

The head pulley should be forced on its shaft as well as keyed. Owing to the sudden shocks to which many elevators are subjected, ordinary keying is not sufficient to keep the head pulley tight. The hood for the receiver is made in two pieces and is open at the top, the two sections fitting snugly around the shaft. The front section is tapered at the forward edges, the point being inside so that the splash of the elevator will not be cast through the opening. The two sections can, of course, be readily removed. It is a very great advantage to be able to look into the elevator and to be able to hear the warning sounds which it gives out. A heavy eye over the top of the elevator is a very great convenience in changing pulleys and shafts and in making repairs. The buckets used for elevators are of steel and malleable iron of the "AA" or deep form. For elevating fine ore the lightness of the steel buckets makes them preferable. Malleable iron buckets are 3/16 in. thick. The steel buckets are of varying gage from 23 to 12, the thickness increasing with the size. The seamless steel bucket is much to be preferred to the riveted type.

DIMENSIONS OF MALLEABLE-IRON ELEVATOR BUCKETS

Length, Inches	Width, Inches	Depth, Inches	Approx. Capacity	
			Cu. In.	Gals.
10	6	5	160	0.61
11	6	5	176	0.66
10	7	5.5	210	0.78
12	6	5	205	0.75
14	6	5	235	0.88
12	7	5.5	260	1.00
14	7	5.5	310	1.16
16	7	5.5	360	1.35
18	7	5.5	410	1.53
12	8	6.5	350	1.31
14	8	6.5	415	1.55
16	8	6.5	480	1.79
18	8	6.5	515	2.03
18	9	9	710	2.63

In ordering a new lot of buckets it is wise to send a templet showing the spacing desired for the double row of holes through which the elevator bolts pass.

DIMENSIONS OF GEARS AND PINIONS

	No. of Teeth	Width of Face, Inches	Bore, Inches	Hub		Arms.
				Width, Inches	Diam., Inches	
Pinion	15	4.0	1 13/16	...	...	...
Gear	60	4.0	3 7/16	5 3/4	6 3/4	6
Pinion	12	4.0	2 7/16	...	...	...
Gear	48	4.0	3 7/16	5 1/4	6 1/2	6
Pinion	18	3.0	2 3/16	...	...	...
Gear	60	3.0	3 1/16	5	7 3/4	Web.

The gearing to be found in mills is generally of cast iron. The accompanying table shows three examples of gear wheels and pinions, and may be of service to those constructing elevators.

Elevators of moderate length can be driven directly with a belt.

Mounting the Belt

The belt is received at the mill in a coil securely sewed up in burlap. If it is to be put into place at once a piece of pipe is slipped through the center and the pipe and belt are suspended on a pair of horses. Horses are set out at regular intervals, on which is placed a line of boards. The belt is then dragged out on the boards, the pipe which serves as a shaft being prevented from advancing by a couple of cleats nailed on the horses. When a good part of the belt is stretched on the boards, it is laid off in equally spaced distances with a pencil and carpenter's square. The writer generally made the distances equal to the width of the belt from one bucket to another.

The effect of wear on the belt due to the bucket can be readily seen on any old belt lying on the scrap heap. Below the position occupied by each bucket is a deep scar, due to the intensity of the scouring action in the boot on these parts, and the chafing of the buckets on the belt, the wear being accentuated by grit lodged between the buckets and the belt. Since the holes in the buckets are larger than the bolts, the buckets are able to shift about to some extent. As the buckets in passing over the upper pulley are thrown out by centrifugal force, the edge of the bucket presses into the belt and tends to break the plies. To a much less degree the backs of the bolts have the same effect. The most dangerous breaks will generally be found just above the buckets.

Because of the effect of wear due to the buckets, and because of the smaller load on the belt with widely spaced buckets, the millman will put them as far apart as possible. It would seem preferable to space the buckets rather widely and increase the belt speed to get a greater capacity.

After the belt is laid off by equidistant pencil lines, a bucket edge is placed up to these lines, and the position of the bolt holes marked on the belt. For punching the holes only the best quality of punch should be used. Bemis & Call's punches, especially those with extra long shank, are very serviceable. The No. 10 punch is the size generally used.

The operations of marking, punching, placing the bolts and buckets and screwing up the nuts can be done most rapidly by a number of men working in succession. The nuts are screwed on with the rounded face to the bucket. The stamping out of the blanks for the nuts leaves a burr which is not ground off by the maker. The brace for tightening the nuts is shown in Fig. 5.

Splicing

If a scarf splice is decided upon, a cut is made across the end of the belt to the depth of the first ply, and at a distance from the end equal to the width of the belt, and the ply is torn off from the cut to the end. A cut is then made in the second ply at a distance from the first equal to the width of the belt divided by the number of plies, less one, and this is then torn off to the end. With this

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same width of step the lower plies are successively removed. Fig. 6 is a diagram showing the completed scarfing for a 20-in. 10-ply belt. The writer's rule for obtaining the proper number of plies for the belt is to divide the width by two.

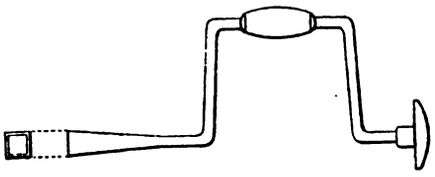

Fig. 5. Brace for Tightening Belt Nuts.

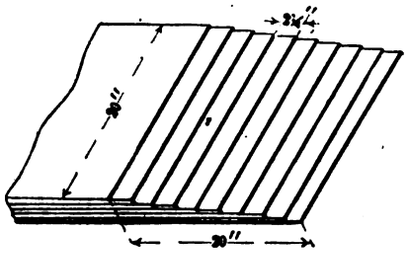

Fig. 6. Scarfing of 10-Ply Belt.

The writer prefers a butt joint with a covering piece equal in length to twice the width of the belt, as shown in Fig. 7. This form of joint is of course much stronger than the scarf joint and should be used on extra heavy belts. Its disadvantages are that a bucket placed on the covering piece is apt to catch on the receiver iron, or, if the covering piece is left blank, an undue strain is thrown on the bucket below the joint every time it dips into the ore in the boot.

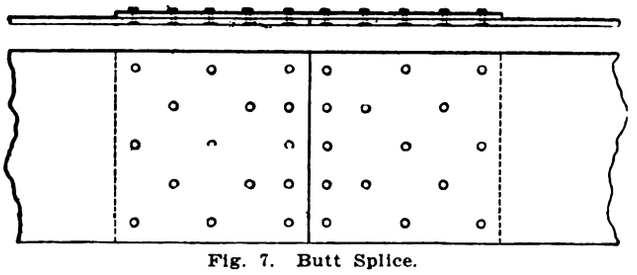

Fig. 7. Butt Splice.

Fig. 8 shows the method of bolting together the scarfed lap joint and the relation of the advance of the ends of the joint upon the head pulley. This is exactly opposite to the principle employed in splicing leather belts, the point being the last part to go on the pulley. There being often considerable slippage on the head pulley of an elevator, and it being impossible to make a bolted joint lie smoothly, a slip of the belt, if the joint was the reverse of that shown in the figure, would cause the end of the belt to roll up. As shown in the figure, a slip of the belt would tend to lay the scarf piece smooth.

Placing a New Belt

If the old belt is still in the housing, it will assist materially in raising the new one; for, if the new belt is attached to the old one at the boot, the latter, after being cut, will very nearly counterpoise the weight of the new one, and as the new belt is raised the old one can be drawn out. Large screw eyes should be placed at convenient points for holding snatch blocks. A rope can then be run over the head pulley and the ends dropped down through the casing and out at the wing openings at the boot, one end being secured to the end bucket on the new belt.

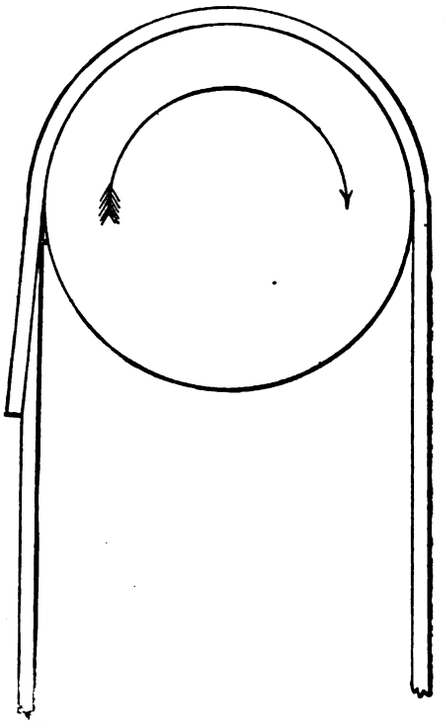

Fig. 8. Advance of Lap on Pulley.

The other end passing out of the boot is caught on the snatch blocks and connected with the winch. Two men will generally stand at the wing openings to pass in the belt, one at the head pulley to see that all is well at that point, and others will man the winch.

When the end reaches the boot pulley it is drawn upon around it, and the clamps put on. Fig. 9 shows a belt clamp. A mill having a number of elevators should have three or four pairs of these clamps. For the heaviest belts a clamp with 1-in. rods with machine-cut threads should be provided. After the belt is stretched the superfluous belting is cut out and the joints are bolted together.

After the belt has been in service a short while the clamps will again have to be put on and another

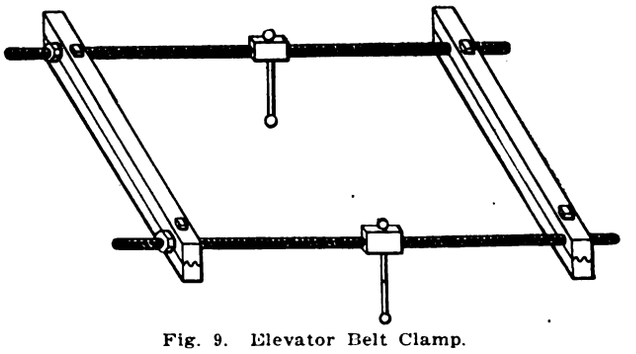

Fig. 9. Elevator Belt Clamp.

piece of the belt removed. If a scarf has been cut the unscarfed end is punched while in the clamps, one man holding a block behind the belt. The two ends are then laid together, and the position of the holes for the scarfed end are marked with red paint. The red paint consists of a little red lead mixed in linseed oil. The covering piece of a butt

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joint is punched before bolting into place. Wood clamps are convenient for holding the joint together while the belt is being marked.

Patching Elevator Belts

Patching is often resorted to to prolong the life of the belt. Not infrequently, owing to the great delays occasioned in getting belting, one is forced to prolong the life of the belt in use. The most dangerous breaks are the horizontal ones across the belt above a bucket. A break of this kind, which appears to penetrate only through the rubber, is often a number of plies deep. The back of the belt is often studded with pieces of ore, which have been forced into the belt, giving the appearance, described by millmen, as "shot." Wherever needed the buckets are removed and a piece of new belting is bolted on to strengthen the belt. No task is so disagreeable as making repairs in a wet elevator housing or raising a fallen belt. The grit-laden drippings on the skin cause an irritation which is the acme of discomfort. While patching the belt is going on, an examination of the boot should be made for broken buckets or anything likely to stall the elevator. If the elevator is the one below the No. 1 rolls, bolts, pieces of drill steel and other iron brought in with the ore from the mine, may be found.

The receiver iron should be given attention. If badly worn it will allow ore to drop into the boot.

Buckets

Elevator buckets dipping into ore wear down most rapidly at the corners. Buckets subjected to much wear and tear should be watched rather closely. After they are worn down to a certain point, putting on new ones will cause the elevator to stall or break the belt. The front of the buckets receiving no support from the worn-down corners is readily doubled up by any obstruction in the boot.

A bucket distorted outwardly is apt to catch on the receiver iron. The writer has seen heavy malleable-iron elevator buckets, of which all that remained attached to the belt was the back plate.

If the elevator is gear-driven, a spare pinion shaft, pinion and pulley complete, should be kept on hand near the receiver ready to be dropped into the boxes in case the teeth of the pinion are stripped or the pinion shaft is broken.

No. 1 elevator was subject to great and sudden shocks, Nos. 3 and 4 were subject to shocks, though in a lesser degree, and No. 2 was free from shocks.

The figures for the first set of gears, given in the table on gears, are for elevator No. 2. The second pair is for elevators Nos. 1 and 3, and the third set is for elevator No. 4.

FOUR ELEVATORS DETAILS AND OPERATION

	No. 1		No. 2		No. 3		No. 4	
Vertical distance between shaft centers	47.83		42.77		31.67		56.92	
	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.
Vertical angle of line connecting centers of pulleys	8	20	11	6	5	7	7	34
Horizontal offset, inches per foot rise	1.76		2.36		1.07		1.59	
Belt: Width, inches	16.0		16.0		16.0		20.0	
Number of plies	8.0		8.0		8.0		10.0	
Travel, feet per minute	440.0		440.0		440.0		500.0	
Buckets: Style	AA		Steel		AA		AA	
Size, inches	8x14		7x14		8x14		8x18	
Spacing, inches	16		16		16		20	
Tons ore raised in 24 hours	700		100		350		350	
Range of size of ore raised (mm.)	60–0		4–0		40–0		40–0	
Tons water raised in 24 hours	601		601		2405		4305	
Gallons of water raised per minute	100		100		400		716	
Head Pulley: Diameter, inches	40		40		40		48	
Face, inches	18		18		18		22	
Bore, inches	3 7/16		3 7/16		3 7/16		4 7/16	
Boot Pulley: Diameter, inches	30		30		36		40	
Face, inches	18		18		18		22	
Bore, inches	3 7/16		3 7/16		3 7/16		3 15/16	
Horsepower	3.50		1.68		4.89		15.0	

WET BUCKET ELEVATOR DESIGN*

The speed at which a wet-bucket elevator should be run, the proper slope for the ascending belt, the question of feeding into the boot or into the bucket, whether the dividing point in the receiver should be high or low, the right and wrong side for the extra rubber cover of the belt, and many other such problems enter into the design of wet-bucket elevators; problems which are all too often left to rule-of-thumb solutions. In studying the underlying theory of the wet-bucket elevator I have come to the conclusions that are here outlined.

Importance of Action of Head Pulley

What takes place at the head pulley where capacity is limited by several conditions is not well understood. It is known that centrifugal force helps the elevator to discharge, and that the force of gravity holds the pulp or liquid level in the bucket when going up and helps it out coming down; it is thought that friction perhaps slows up the discharge. Of the magnitude and relations of these forces our information is rather limited.

After the elevator bucket reaches the head pulley both the force of gravity and centrifugal force are acting on the pulp in the bucket, the former tending to hold it down in the bucket with its surface horizontal, the latter tending to pile it up against the discharge side of the bucket. As for friction, it will be found upon investigation that the velocity of the pulp with relation to the bucket, as well as the pressure between the pulp and the bucket, is low when they part company, and the distance passed over in contact is so short, that friction can be dismissed as having practically no effect on capacity or discharge.

The ordinary elevator bucket of malleable iron or pressed steel has a section about as shown in Fig. 1, the angle of inclination Z of the outer face being about 30°. The force of gravity acting on any particle in the bucket is the weight W of that particle, always constant and always acting downward. Centrifugal force C is always a radial from the center of the pulley, and its magnitude is determined by the formula,

$$C = \frac{Wv^2}{gr}$$

where C equals centrifugal force in lb.; W equals weight, or force of gravity in lb.; v equals velocity

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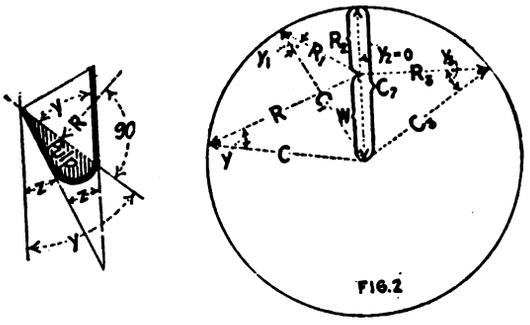
in feet per second; g equals 32.2, the acceleration of gravity; and r equals radius in feet, of path of particle.



Figs. 1 and 2. Forces Acting on Pulp in Elevator Buckets.

The resultant R of these two forces C and W is constantly changing in magnitude and direction as the bucket carries the particle around the pulley. The level of the liquid is always at right angles to the resultant force acting upon it, and with a varying resultant, the surface will change with reference to the tangent of the pulley. The volume carried in the bucket will be limited by the sides of the bucket and, as shown in Fig. 1, a plane perpendicular to R. As the centrifugal forces on the particle at all points pass through a common center and are equal in magnitude, the two forces C and W are combined in the accompanying diagrams, about this center, the resultant R extending from the upper end of the vertical line representing the weight W, and ending at the circumference at a point corresponding to the angular position of the particle, the radial distance being equal to the centrifugal force C. The angle y, Fig. 1, between the surface of the pulp and the tangent to the circle of motion of the particle X is always equal to the angle y between the lines of the forces R and C (Fig. 2), each of the former being, respectively, perpendicular to each of the latter. From Fig. 1 it will be noted that as the angle y decreases, the volume of pulp possible in the bucket decreases, allowing the surplus to slip over the lip of the bucket and to be discharged; when y becomes equal to Z the bucket has no capacity whatever.

From Fig. 2 it will be noted that R is least at the top position and greater at lower positions no matter what the relative magnitudes of C and W, that R tends to hold the pulp in the ascending bucket and discharge it from the descending. When C is less than W, R is downward at the top tending to empty the bucket onto the belt and to let it slop over the sides of the pulley. When C is greater than W, R is directly upward at the top position tending to push the pulp out of the bucket in that direction. When C is equal to W, R is equal to zero at the top position and the pulp is released from pressure against the bucket, and travels under the influence of the velocity it has, that of the bucket, and of the force of gravity. It is apparent that operation under this last condition will be near to that required for best results, the pulp will not fall onto the belt, the discharge will be free, and the buckets will have good capacity.

For this last condition, namely that centrifugal force be equal to the force of gravity, that is, $W = C = \frac{Wv^2}{gr}$ the velocities V in feet per minute, equal to 241 times the square root of diameter in feet of the bucket tip have been called "critical speeds," and the values have been plotted in Fig. 3 for different pulley diameters, speed and diameter being given in the form most advantageous in practice. It is here assumed that the pulp particles take the velocity of the bucket tip, which is substantially correct for the conditions which are being considered.

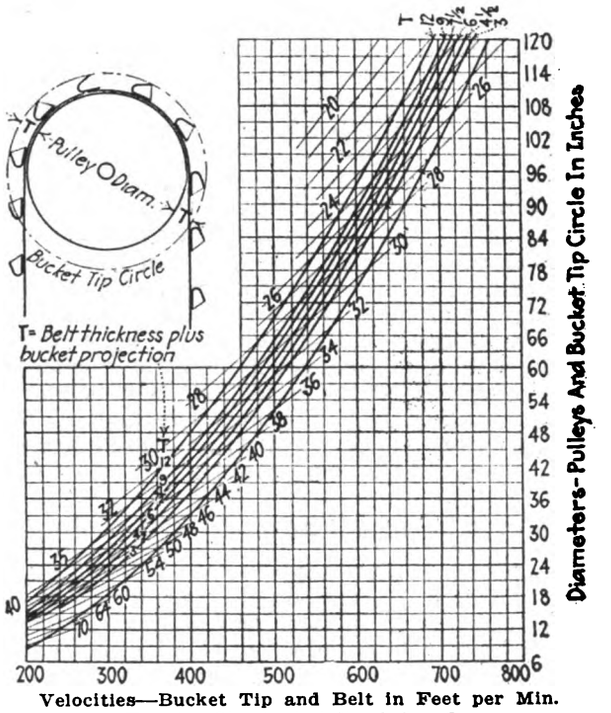


Fig. 3. Chart of Critical Speeds.

As the velocity of the belt and pulley is less than that of the bucket tip, additional curves have been drawn for the pulley diameters when belt thickness and bucket projection are allowed for. The curves give both the belt velocities and the revolutions per minute of the pulley for the different values of T (belt thickness plus bucket projection, in inches) of 3, 4½, 6, 7½, 9 and 12 in., when the bucket tip is traveling at the critical speed.

Many belt elevators in practice, operating at belt speeds from 300 to 400 ft. per min. will check fairly well with these curves; those at speeds above 400 ft. per min. are either running too fast or have pulleys too small for the belt speed. Present-day practice has been slowly and cautiously increasing velocities and pulley diameters, the curves show what changes can be made to increase capacity along rational lines.

In some plants elevators are reported running at 25 to 40% overspeed; critical speed equals 100%, and high hoods are required. This suggested a study of discharge points and of bucket capacities as affected by overspeeds, and the results as shown in Fig. 4 clearly indicate that these particular elevators were letting go of much if not all of their pulp just after the bucket reached the head pulley, probably recovering some of it to discharge nearer the receiver.

Effects of Overspeeds

In explanation of Fig. 4, it will be recalled that the resultant R of the two forces C and W is changing in magnitude and direction as the pulley re-

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volves, and it is the direction of R that is of interest. At the critical speed a bucket traveling vertically, around the pulley, has its resultant R at 45° from the horizontal, which means that the pulp in the bucket assumes this angle on its surface. At overspeeds R is flatter, the pulp lies in the bucket at a steeper angle and capacity is less. As the bucket travels upward around the pulley the angle of R does not increase as rapidly as the pulley turns, so that up to a certain point its capacity increases, then it gradually decreases until discharged.

As before stated, the angle y is that between the surface of the pulp and the instantaneous direction in which it is moving. It varies, of course, with R, and its values are shown in Fig. 4 for the different angular positions as the bucket travels up to the top of the pulley, at the critical speed and at overspeeds. These y curves are found to be true circles passing through the center and top points of the critical-speed circle, and with centers at the intersections of lines drawn from these two points at angles y from the horizontal. The overspeed curves are lines of equal centrifugal force measured from the center of the circle. It will be noticed that the distance between them increases as overspeed increases, because centrifugal force increases as the square of the velocity.

Examples of Overspeed Effects

Using Fig. 4, what happens, say with 20% overspeed will now be explained. When the bucket reaches the head pulley the surface suddenly changes from a horizontal position to one inclined about 36° from the vertical, and likely the shock will throw some of the pulp up on a still steeper angle. As the pulley turns and the bucket reaches a point 20° from the horizontal the surface of the pulp has subsided to an angle inclined 40° from its direction of travel, half way up the surface angle is 43° and then it decreases to 40° at two-thirds up and then to 35° at 70° up the arc, then 29° at 75° up, and 22° at 80° up. Discharge has taken place when the surface of the pulp is parallel to the face of the bucket, that is, when y equals Z in Figs. 1 and 4. If Z is 30°, then discharge has taken place before the bucket is 75° up the arc. By the discharge taking place, is meant the point where pressure ceases between the pulp and the bucket and the pulp is free to leave, although it will be some little distance and time before they will actually have separated.

If a bucket with an angle Z equal to 25° have an overspeed of 40%, it will discharge all of its pulp at contact with the pulley, the belt rising vertically to the pulley, it will perhaps recover some of it at 15° up and discharge again 40° up the arc, and it holds nothing on an angle Y greater than 31°. The surface of the pulp may be slightly curved and very likely as discharged will be elongated over the length of the face of the bucket. It does not seem that this would affect materially the point of division between the down-going buckets and the discharged pulp going into the receiver. I have been told that this point of division should be but little lower than the center line of the shaft, that it should be on a 45° angle from this, that it should be on a level with the bottom of the pulley, and again that it should be on a 45° angle tangent to the pulley. Two or three wet elevators that I have designed on the last basis discharged beautifully, but I am satisfied that the troubles of sampling-mill practice were responsible for this low discharge and that in wet mills such extreme precautions are not needed.

In Fig. 5 are drawn various pulleys, with the paths followed by the pulp particles leaving the bucket tip at critical speeds plotted to the same scale; three curves are also drawn in dash lines showing paths followed when discharged 60° up

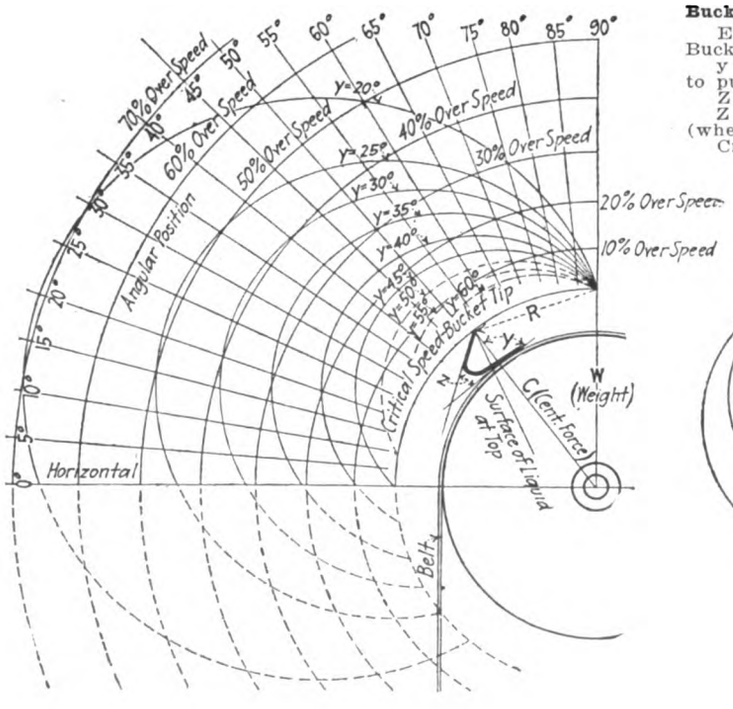

Fig. 4. Forces Acting on Contents of Buckets Ascending Head Pulley.

Bucket Capaacities and Discharge Points

Effect of Speed Increase at Head Pulley (and Shape of Bucket).

y = Angle between liquid surface in bucket and tanget to to pulley or tip circle.

Z = Angle between front and back faces of bucket.

Z = y at points of intersection speed and bucket angle y (when bucket releases load).

Critical Speed: When Centrifugal Force = weight.

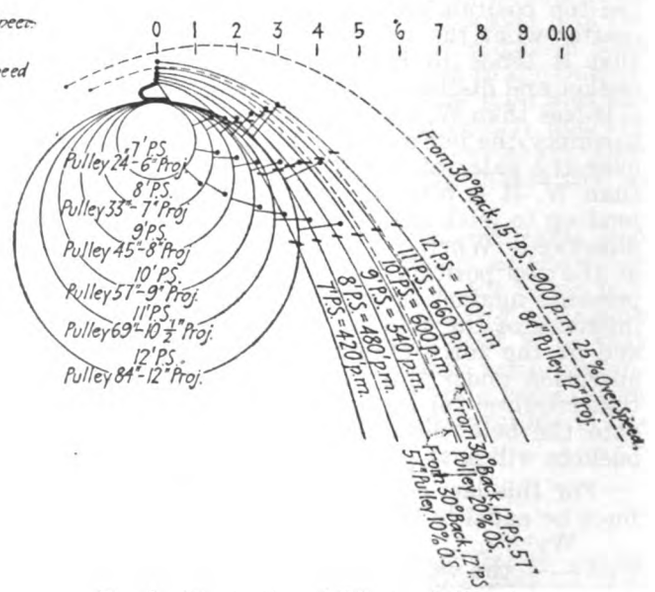

Fig. 5. Illustration of Effects of Charging Discharge Conditions.

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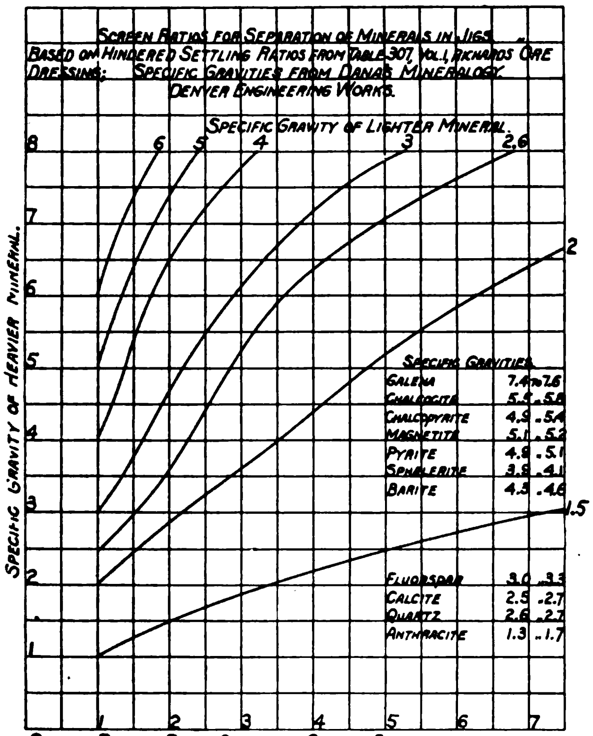
the arc by overspeeds. Critical speeds of 7, 8, 9, 10 and 12 ft. per sec. have been taken, corresponding to pulleys 24, 33, 45, 57, 69 and 84 in. diameter, with belt and bucket projections 6, 7, 8, 9, 10½ and 12 in., respectively. The location of the discharging masses and also of the bucket tips are shown ¼, ⅜ and ½ sec. after leaving top position. The discharging mass is shown elongated partly to call attention to it, the shape of the mass is open to question. One who has listened to the discharge of an elevator knows that discharge takes place in masses rather than in a thin stream.

From these curves in Fig. 5, it can be seen that the divider placed on a horizontal line with the center of the pulley will make a good separation, provided the elevator be running up to critical speed. If below critical speed, the pulp which has fallen on the belt is discharged at the velocity of the belt and not of the bucket tip, and in consequence it does not start as high up nor go nearly so far out in discharging. As the coarser sand which may have settled in the bucket would naturally discharge last, the error is made on the safe side when the divider is placed lower. Then observations on the position of the divider do not apply to so called dry ores, where a little moisture often requires a low divider.

The following conclusions can be drawn from what has been stated. The velocity of the bucket tip should not be less than the critical speeds given in Fig. 3, and not more than 5 to 10% greater. Overspeeds reduce bucket capacity and help discharge but little. In elevating water and non-settling pulps, the outer face of the bucket should be nearly parallel with the belt face, as the capacity is in the lower front corner, and the slope of the outer face does not assist discharge. For pulp in which the sand may settle out it may be necessary to stick to the present type of bucket. With the change in bucket shapes suggested, about double carrying capacity per bucket could be obtained. Bucket capacities should be stated on the basis of a line drawn from the tip at an angle of 45° with the belt face, this being the maximum possible capacity for wet elevators running vertically. The diameter of the head pulley must be taken into account in every calculation, it is fully as important as belt speed. By increasing the diameter, the belt speed can be increased, giving greater capacity. Increased diameters will be easier on the belts. Unless the buckets finish loading after leaving the contact with the boot pulley, the latter should have the same diameter as the head pulley. The inclination of the ascending belts will allow the buckets to retain a greater portion of their load as they reach the head pulley. Discharge is not affected by inclination on the descending side. Capacity is proportional to belt speed, which can be greatly increased only by increasing the diameter of the head pulley. Bucket capacity can be greatly increased by making the section nearly rectangular. With decreased weight of bucket for equal capacity and with higher speeds, belt wear will be reduced, and narrower belts can be used.

Screen Openings for Sizing Jig Feeds

The practical mill operator desires to know how great a range of size of particles may be fed to a jig without interfering with perfect jigging—which means what mesh screens to use to prepare the ore for feeding to the jigs. We have devised a diagram, 0237, from which may be obtained the exact information required for any ore.



SCREEN RATIO = DIA. OF OPENING IN COARSER SCREEN. / DIA. OF OPENING IN FINER SCREEN. 0237

This diagram is based on the laws of "Hindered Settling" (jigging) and on "Hindered Settling Ratios" determined by Dr. Richards, all of which will be found in Chapters 14 and 15, Vol. I, and Chapters 25 and 36, Vol. III, Richards "Ore Dressing."

To use this Screen Ratio Diagram it is necessary first to know the physical composition of your ore, that is, what minerals and gangues will be separated or liberated by crushing. Then must be found the specific gravity of each component by referring to the specific gravity table.

Suppose, for example, your ore when crushed separates into particles of pyrite and particles of quartz gangue. From the table the specific gravity of pyrite is 5.0 and the specific gravity of quartz is 2.6. Now, referring to the diagram 0237, find 5.0 on the left and follow the horizontal line to the point where it meets the curve 2.6, then down vertically to the bottom of the diagram, which would be 2.8.

2.8 is the greatest screen ratio allowable in this case, but for safety we will use 2. This means that the largest particle in the jig feed must not be more than twice the diameter of the smallest particle in the same feed.

If it has been decided that profitable jigging may commence with ore crushed to ½-inch, then the first screening of jig feed would be through ½-inch, and on one-half of ½ or ¼-inch opening.

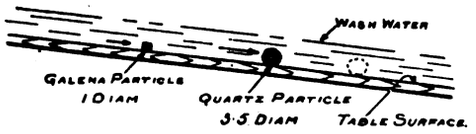
The next screening would be through ¼ and on one-half of ¼ or ⅛-inch. For an ore composed of galena and quartz the greatest ratio will be found to be 5.75, but for safety use 4.

Courtesy Denver Eng. Works.

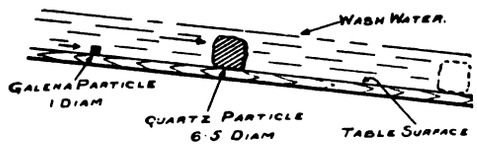
FREE SETTLING AND HINDERED SETTLING

The hydraulic classification of ore pulps comprises two methods, one known as "free settling" and the other as "hindered settling."

Assume an ore consisting of but two elements, galena and quartz, and after crushing it to a suitable size, feed this pulp to the common form of "Spitzkasten" or pointed box classifier of the "free settling" type; then a particle of galena 1 mm. in diameter will fall through the water with a particle of quartz 3.5 mm. diameter—and this ratio 1 to 3.5 is the "free settling" ratio for galena and quartz.



Feeding the same galena-quartz ore to a classifier, such as the Richards Pulsator, will, by means of the pulsating current, subject the ore to "hindered settling" conditions, and a particle of galena 1 mm. diameter will fall through the pulsating current with a particle of quartz 6.5 mm. diameter. This ratio of 1 to 6.5 is the "hindered settling" ratio for galena and quartz.



Thus the "hindered settling" conditions deliver from each classifier compartment a pulp in which the gangue particles are nearly twice as large as would be the conditions under "free settling." This increase in the diameter of the gangue particle has an important bearing on the increased recovery of values and particularly in the separation of one mineral from another on the same table.

TABLE OF HINDERED-SETTLING FACTORS

Hindered-Settling Factors, or Multipliers for Obtaining the Approximate Diameter of the Particles of Quartz Settling in a Mass of Grains That Will be in Equilibrium With, and Adjacent to, the Mineral Specified:

Copper	8.6
Galena	5.8
Wolframite	5.2
Antimony	4.9
Cassiterite	4.7
Arsenopyrite	3.7
Chalcocite	3.1
Pyrrhotite	2.8
Sphalerite (blende)	2.1
Epidote	1.6

Example—If mixed grains of quartz and galena are allowed to arrange themselves in a mass, hindering and elbowing one another all the time, in an upward-moving current of water, the quartz particles, when equilibrium is reached, will be found to have approximately 5.8 times the diameter of the particles of galena poised alongside of them.

SCREEN MESH AND MAXIMUM SIZE OF PARTICLES PASSING THROUGH THE SCREEN

Heavy Mining Grade—Steel Wire—Washburn & Moen Gauge

No. of Mesh	Gauge No. of Wire	Diameter of Wire, Inches	Maximum Size of Particle	
			Inches	Millimeters
4	12	0.105	0.170	4.32
5	13	.092	.108	2.74
6	14	.080	.085	3.15
7	15	.072	.078	1.98
8	16	.063	.053	1.34
10	18	.047	.053	1.34
12	19	.041	.041	1.04
14	20	.035	.036	.92
16	22	.028	.028	.71
18	23	.025	.025	.63
20	24	.023	.023	.58
24	26	.018	.018	.46
30	30	.014	.014	.35
35	31	.0135	.0135	.34
40	32	.013	.013	.33

TABLE OF FREE-SETTLING FACTORS

Free-Settling Factors, or Multipliers for Obtaining the Diameters of Quartz Which Will be Equal-Settling with the Mineral Specified When Settling Freely in Ample Water.

	VELOCITY IN INCHES PER SECOND								
	1	2	3	4	5	6	7	8	9
	MULTIPLIERS								
Anthracite	.500	.353	.225	.213	....	....	....	....	....
Epidote	1.57	1.35	1.05	1.13	1.50	1.61	1.56	1.56	1.47
Sphaelrite	....	1.46	1.05	1.17	1.62	1.64	1.63	1.66	1.56
Pyrrhotite	....	1.73	1.29	1.48	2.00	2.22	2.26	2.13	2.08
Chalcocite	....	1.90	1.47	1.62	2.07	2.28	2.41	2.44	2.17
Arsenopyrite	....	1.90	1.57	1.89	2.42	2.56	2.72	2.84	2.94
Cassiterite	....	2.11	1.79	2.00	2.73	2.93	3.03	3.05	3.12
Antimony	....	2.71	2.00	2.00	2.73	2.93	3.03	2.98	3.00
Wolframite	....	2.71	1.83	2.07	2.86	3.04	3.21	3.28	3.26
Galena	....	2.71	1.83	2.26	3.00	3.42	3.65	3.76	3.75
Copper	....	2.71	2.00	2.36	3.00	3.20	3.58	3.76	3.75

Example—If a compact particle of galena, falling freely in water, settles 7 inches per second, the particle of quartz of the same shape that will settle at the same rate will be approximately 3.65 times the diameter of the galena.

NOTE—Tables above are from a paper in the Transactions of American Institute of Mining Engineers, "Close Sizing Before Jigging," by Prof. Robert H. Richards.

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FREE AND HINDERED SETTLING OF MINERAL GRAINS*

At the meeting of The American Institute of Mining Engineers, held in New York, April, 1907, Prof. Robert H. Richards, of the Massachusetts Institute of Technology, presented a paper entitled, "Velocity of Galena and Quartz Falling in Water," in which he described a series of experiments carried out under his directions. Since that time his interest has been drawn to work on the laws of hindered-settling. He has invented a hindred-settling classifier, and has done considerable experimental work to find the hindered-settling ratio of quartz and galena.

While working in Professor Richards' employ on this classifier I became interested to work out this ratio mathematically, and, if possible, the theoretical, i. e., mathematical, explanation of this hindered-settling action.

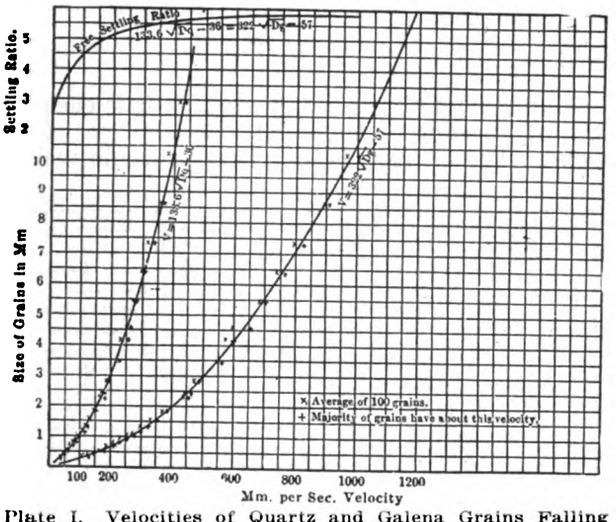

Plate I. Velocities of Quartz and Galena Grains Falling Freely in Water.

This paper first gives in plotted form—Plates I to IV—data taken from the paper by Professor Richards on the velocities of galena and quartz grains settling freely in water; along with a discussion of free-settling, and the derivation of formulas to express these velocities. With these as a basis, a method is given for working out the hindered-settling velocities and general conditions for quartz and galena, or incidentally any two minerals.

Free-Settling

By the term, velocity of a grain, is meant the velocity which a grain attains when falling in water. It is the same thing as the velocity of the rising current necessary to keep the grain from either sinking or being carried up. This maximum velocity of the sinking grain is attained after a fall of about 2 ft., depending on the size of the grain.

In Plates I to IV, inclusive, the little cross marks (x) represent the average diameter corresponding to the horizontal position of the cross. To judge the

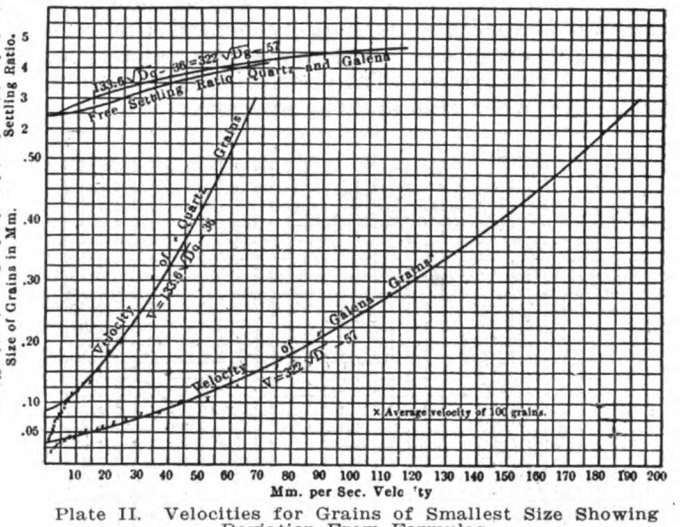

Plate II. Velocities for Grains of Smallest Size Showing Deviation From Formulas.

reliability of these averages, or any law derived from this data, it seems necessary to know the average deviation of the individual velocities from these averages as given. Therefore, in Plate III, in each case the average deviation of the 100 grains is denoted by a dot and circle on each side of the cross. This deviation in velocity is due largely to the differing shapes of the grains, but also is due in part to the range in the size of the grains taken.

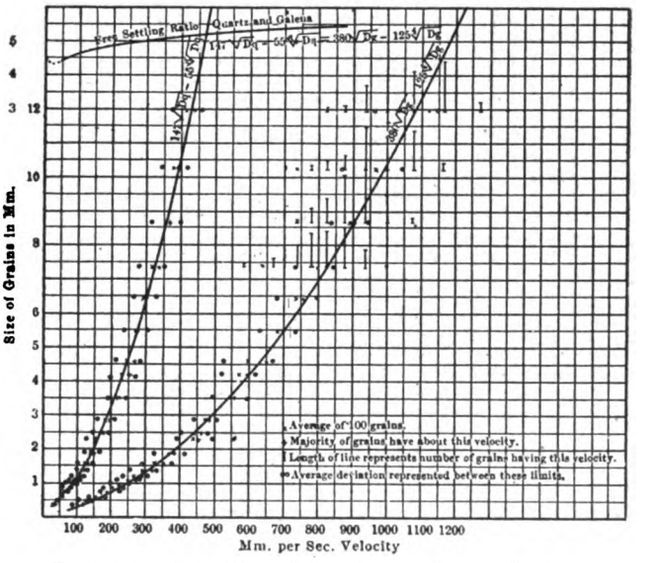

Plate III. Velocities of Quartz and Galena Grains Falling Freely in Water.

For example, the grains plotted as having an everage diameter of 11.93 mm. are, in fact, anywhere from 11 to 12.9 mm. in size. A closer sizing would give a smaller deviation in velocities. As it is impossible to calibrate the screens used for sieving precisely, variations of averages from the curve are, in part, due to this error.

*By Arthur O. Christensen in Eng. and Min. Journal.

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In the case of the four largest sizes of galena grains in Plate III vertical lines represent by their length the number of grains having velocities corresponding to the horizontal position of these lines. An examination of these shows how the bulk of the grains have velocities greater than the average. It is a question whether to plot the velocities from the mass of grains in each case, or to take the average velocities, which are dragged down by some odd shaped grains lagging behind the rest. An upright cross (+) represents the velocity of the bulk of the grains. The curves plotted are compromises between this and the average.

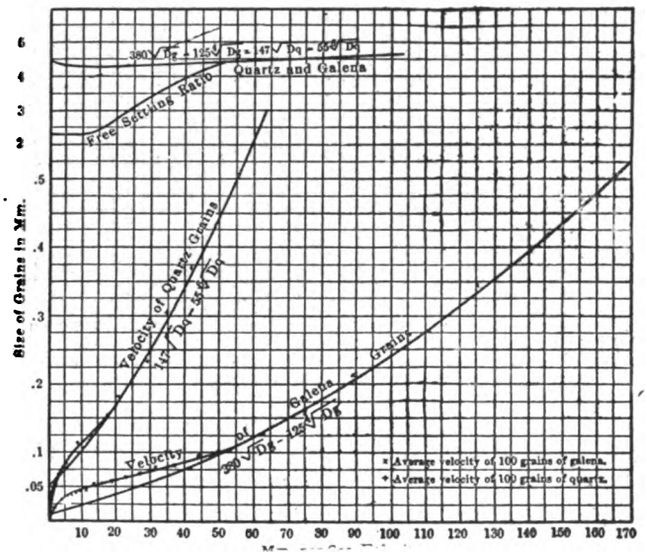

Plate IV. Velocities for Grains Smaller Than 0.15 mm. Showing Deviation From Formulas.

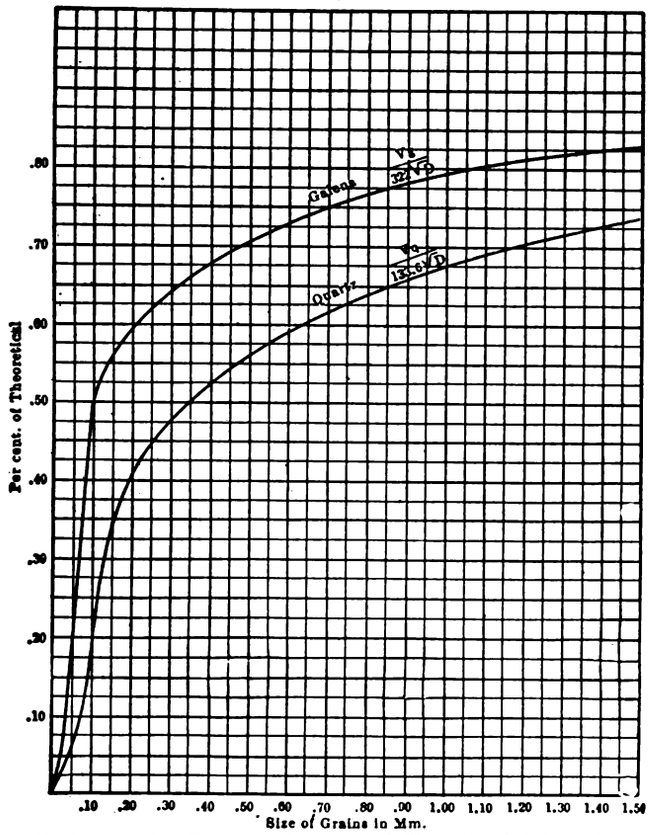

Plate V. Per Cent. of Theoretical Velocity Attained by Grains Falling Freely in Water.

In making Plate III especial pains were taken to show that the velocity of any size of quartz or galena grain can be stated quite accurately from its diameter. The mathematical curves representing the velocities as plotted on Plates I and III are seen to lie well within the average deviations of the velocity in each case, and in most cases between the average velocity and velocity of the bulk of the grains.

Rittinger is still often quoted as having established the law for the velocities of grains of mineral falling freely in water. He assumed the grain to be a cube, falling with faces horizontal and vertical, in which case, falling at maximum velocity, the weight of the grain in water is equal to the area of a face, multiplied by the head of water required to hold it up. This head is here a velocity head, being known from the formula:

$$V = \sqrt{2gh}; \quad h = \frac{V^2}{2g}$$

Thus

$$D^3 (G - 1) = \frac{V^2}{2g} D^2; \quad 2gD (G - 1) = V^2$$

$$V = 140 \sqrt{D (G - 1)}$$

D = diameter of the grain in mm., in this case the length of an edge of the cube. G = sp. gr. of the mineral. Therefore (G — 1) is its specific weight

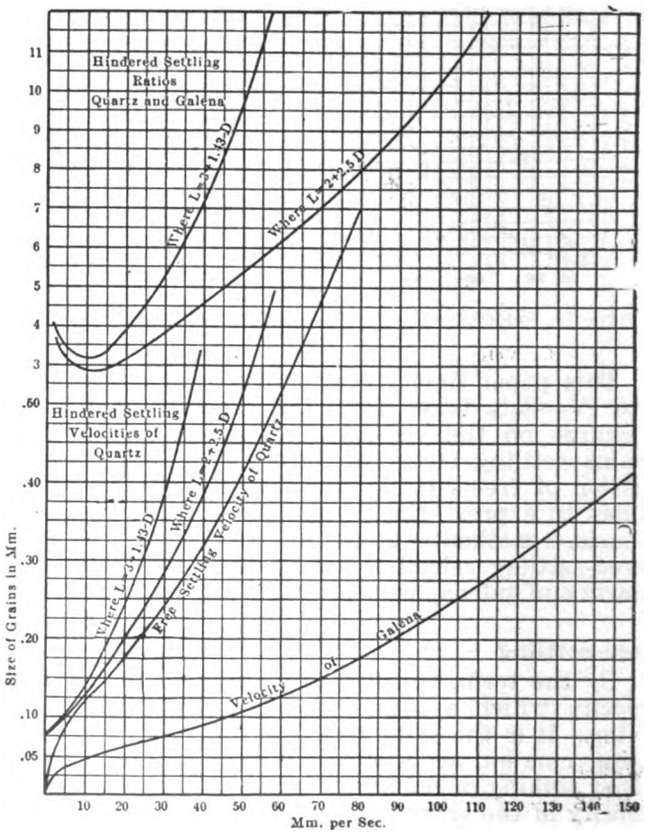

Plate VII. Hindered Settling Ratios of Quartz and Galena and Settling Velocities.

in water. V = velocity attained in mm. per sec., or the current necessary to support the grain. g = acceleration due to gravity: i. e., 9800 mm. per

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sec. As this equation gives velocities far too high, Rittinger substitutes for the 140 a factor C which varies from 61 to 87, according to the shape of the grains. In any case, whether we assume the grain a cube falling with one corner down, as it would naturally fall, or a sphere, or an ellipse, his formula, derived from a purely theoretical consideration, is the equation for a parabola. No parabola, however, can be plotted which will even lie between the average deviations of the velocities of the grains. In other words, the experimental precision warrants an equation much more precise than any of Rittinger's.

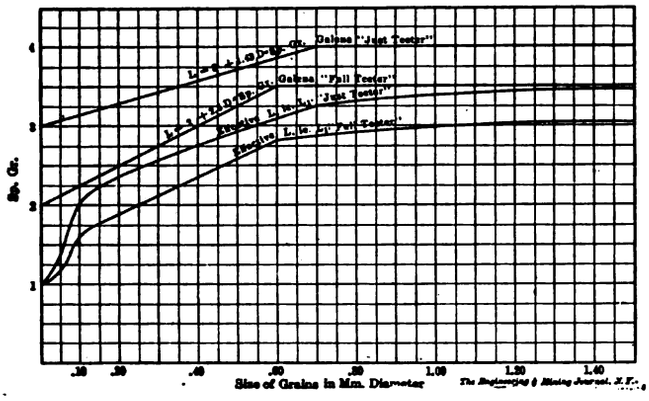

Plate VI. Specific Gravities and Effective Specific Gravities for Columns of Teetering Galena.

If we sieve a crushed mineral through a series of sieves and weigh a known number of the different sizes of grains we would probably expect that the weights would vary as the cube of the diameter varied, and would follow the equation

$$W = \frac{3.1416\ D^3}{6} G,$$ where W is the weight of the grain, D the mean between the diameter of the last sieve which the grain passed and that of the sieve which it was caught on, and G is the sp. gr. of the mineral in question. This, however, is not the case. Here the cleavage of the mineral comes into play. The weight of a cube is almost twice that of a sphere of given diameter. The weight of an ellipsoid is greater or less than that of a sphere depending on which axis of the ellipsoid we take as its diameter.

If we take a mineral sized through a series of sieves, and weigh a definite number of each size grains, a plot showing the weight of the sizes will vary as the cube of the diameter of the grains, but will not coincide with the formula

$$W = \frac{3.1416\ D^3}{6} G,$$ which assumes the grains spheres. Of course the curve will depend, in part, on how the mineral was sieved. By the gentlest sieving the weight of the grains will be lower than if rough and repeated sieving was done. By using comparatively gentle sieving it has been found that for quartz, $W = 1.15D^3$, expresses the weight of the grains in terms of its diameter, the quantities being in millimeters and milligrams. For galena the weight is $W = 4.8D^3$. The weight of the galena grains is above, and of the quartz below the values expressed by the equation

$$W = \frac{3.1416\ D^3}{6} G,$$ which are 3.93 and 1.39 respectively. This is what we should expect, as galena tends to break into cubes and quartz into ellipsoids and lath-shaped pieces of all manner of irregular shapes, which, when sieved gently, have a weight, in proportion to their diameters, less than what spheres of quartz would have. The same is the case with pyrite grains, or crushed slag.

If, from these equations for the weights of quartz and galena grains, we should derive equations for the velocities of the grains falling in water we might claim to have the most accurate equations which could be derived from purely theoretical considerations. If $W = 1.15\,D^3$ is the weight of the quartz grain in air its weight in water (Ww) would be:

$$Ww = 1.15D^3 \frac{G-1}{G} = 0.716D^3.$$ Equating the weight of the grain to the head of water impinging against its horizontal cross section we get:

$$0.716\ D^3 = \frac{3.1416}{4} D^2 \frac{V^2}{2g};$$

$$V = 133.6 \sqrt{D}.$$

Similarly for galena we can derive the equation $V = 322 \sqrt{D}$ from the formula $Wg = 4.8D^3$.

Factors Effecting Velocity of Falling Grain

Going further into the consideration of the factors acting when a grain is falling in water we see there are at least two more elements which enter. On the one hand, the weight of the grain in water is the only element forcing it down, so on the one side of the equation we may feel secure in placing Ww, or its equivalent $0.716\ D^3$ for quartz, and $4.16\ D^3$ for galena. On the other side there is the impact of the rising water against the horizontal section of the grain. This is an uncertain quantity. In fact it varies constantly as the grain revolves and twists while sinking. Here this section has been assumed a circle, which for the present seems as accurate as can be stated, although probably, as with the weight, the cleavage again enters.

Then, every grain is known to retain a film of water about it. This film may not be sharply defined, but the water immediately next to the grain stays with it; that not so close tends to stay with it, but may be dragged away; and the water outside of this may merely be dragged along for a short distance with the grain. The effect is that of a film of a definite thickness.

The action is well illustrated by beach sand. It is to be observed that beach sand does not wear down indefinitely, but after a certain fineness the grains are protected from further wear by a film of

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water. This film tends, in the case of grains sinking in water, to increase the diameter, and consequently the horizontal cross-section without increasing the weight. In the case of the larger sized grains this effect may be small, but in the case of the smaller ones it is an important factor.

Another influence seems to enter into the sinking ability of the finest grains. The water seems to have a power of cohesion which must be overcome by the grains. The smallest ones seem to be almost entirely unable to force the water apart. This is illustrated in the case of slimes which will hardly settle at all unless some salt, such as soda-alum, be added to the solution. This salt seems to destroy the water's power of cohesion. For example, grains of galena 0.03 mm. in size have the velocity which a grain of that weight and 0.5 mm. in size would have if it was merely a case of the weight acting against the impact of rising current. Grains of quartz 0.03 mm. in diameter have the velocities which would be expected of grains 1 mm. diameter and of that weight.

For the larger grains the viscosity of the water enters into account. There is a resistance offered by the water, which increases as the velocity of the grains increases. This effect acting on the larger grains, and the effect of cohesion, and a film adhering to the grain, acting on the smaller ones, is found to cause a nearly constant loss in velocity for all grains having a velocity above 5 mm. per sec., according to the results obtained by Professor Richards.

Equations Derived for Free-Settling Velocity of Grains

Thus if we subtract 36 from the equation which we derived from quartz, and 57 from that for galena we get the equations: $V_q = 133.6 \sqrt{D_q} - 36$ and $V_g = 322 \sqrt{D_g} - 57$. As seen on Plates I and II these equations fit the results found from experiment admirably well. Generalizing these equations so as to have an equation to hold for all minerals we get:

$$V = \sqrt{\frac{W\,(G-1)}{D^2 G}\,\frac{8g}{3.1416}} -$$

$$(0.1115 \sqrt{\frac{W\,(G-1)}{D^2 G}\,\frac{8g}{3.1416}} \div D + 21.10) =$$

$$158 \sqrt{\frac{Ww}{D^2}} - (17.6 \sqrt{\frac{Ww}{D}} \div D + 21.10)$$

An attempt was made to derive formulas which should be more exact than these.

The equations $V_q = 147 \sqrt{D_q} - 55^6 \sqrt{D}$ and $V_g = 380 \sqrt{D_g} - 125^4 \sqrt{D_g}$ were found to be about the best empirical formulas which could be derived for the velocities of quartz and galena sinking in water. They are plotted on Plates III and IV and are seen to hold very well for all grains above 0.1 mm. diameter. The equation $V = 147 \sqrt{D}$ is what would be derived, assuming the quartz grains to be spheres with no adhesion, cohesion, friction, etc., entering into consideration.

For the smallest grains both of the above sets of formulas fail, and we must use the formulas $V = 700\ D^2$ for quartz, and $V = 4000\ D^2$ for galena.

For grains of quartz and galena having equal settling velocities the equations may be combined thus: $133.6 \sqrt{D_q} - 36 = 322 \sqrt{D_g} - 57$. Substituting values for D_g we get corresponding values for D_q. $D_q D_g$ is the free-settling ratio of quartz and galena. This ratio is plotted on Plates I and II. In the case of the smaller grains, Plate II also gives the ratio as computed from the plotted values, thus showing the variance of the actual ratio from that derived from the formulas. Plates III and IV show the same as Plates I and II using the more exact formulas.

In the case of the smallest grains the ratio figures out

$$700\ D_q^2 = 4000\ D_q^2; \qquad D_q^2 = \frac{4000}{700} D_g^2 = 5.71\ D_g^2;$$

$$D_q = 2.39\ D_g \frac{D_q}{D_g} = 2.39 = R.$$

The free-settling ratio for the smallest grains seems to be a constant, i. e., 2.4.

Hindered Settling

In Fig. 1 is represented, diagrammatically, a tube having a constriction at the lower end. The area of this constricted end is about one-quarter the area of the cross section of the rest of the tube. A current of water runs from the bottom and overflows over the top. A mixture of crushed quartz and galena, for example, below, say, 2 mm. diameter, has been put into the tube. The velocity of the current rising through the constricted area of the tube is such that the heaviest grains just cannot fall through it. From Plate I or Plate III we see that this velocity, since the largest galena grains are 2 mm. diameter, must be 400 mm. per second.

In the tube the larger and heavier grains find their way to the bottom, the lighter ones are forced up. A state of equilibrium is reached where the actual velocity rising through any section of the tube is just sufficient to support the grains which are occupying that section. Thus we notice that toward the bottom of the column the grains are more compact than higher up. Perhaps the condition of the grains near the bottom could be described by the term, "just not teeter"; those a little higher up "just teeter"; and still higher as "full teeter," whereas the grains at the top of the tube would be so widely separated from one another as to be called "free-settling."

The point to be noticed in this condition is that the grains of quartz which find their place at a certain hight of the tube are of such a size that their free-settling velocity is very much greater than that of the galena grains which occupy the same position in the tube, when the system is in equilibrium. It might be supposed that grains having the same settling velocities would occupy the same portion of the tube. Such is not the case, and it is in this action that hindered-settling obeys different

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laws from free-settling. The larger grains of the lighter mineral are forced up by the smaller grains of the heavier mineral.

The effect of maintaining a column of teetering grains is that of establishing a liquid whose specific gravity is equal to the total specific gravity of this teetering column, with modifications which will be considered below, and whose viscosity is that of water, as it is a case of the current rising against the grain which is trying to sink through it, rather than that of the grain falling freely through a quiet liquid.

Experiments carried out especially for this paper give data as shown on Plate VI. If a column of teetering grains of galena is maintained so that each grain seems to be supported freely by the current, and not at all resting on any grains below it, we have a state which is here called full teeter. For grains below 0.6 mm. diameter the specific gravity of such teetering columns, which is symbolized as L, varies directly from 2 to 3.5 as the diameter of the grain increases. Therefore $L = 2 + 2.5\,D$. For teetering columns of grains larger than 0.6 mm. the specific gravity, under these conditions, is 3.5. The increase in specific gravity of the teetering column due to the galena thus varies from 1 to 2.5.

For purposes of hindered-settling it does not seem necessary to keep the grains so actively teetering. If they can be kept at just enough of a teeter so that any large grain can readily find its way through the column we have that state of highest efficiency of the teetering column, for then it has the highest possible specific gravity, and yet is capable of doing its work, which is, in part, to allow all grains of a higher hindered-settling velocity than those of which it is composed, to pass through. This condition is called, just teeter. For lack of time this state was not thoroughly tried out. Further experiment may show that a still higher specific gravity may be maintained in the teetering column, without destroying its efficiency. The condition of just teeter seems to have a specific gravity varying from 3 to 4 as the grains vary from 0 to 0.70 mm., in $L = 3 + 1.43\,D$. For larger grains the specific gravity remains at 4.

The effect of the increase in the specific gravity of the teetering column, due to the galena in it, is diminished by the fact that the velocity of these grains is less than their theoretical velocity. If their actual velocity is only a half of their theoretical, the increased specific gravity due to their presence will be only half available.

Let us imagine a tube containing granulated iron suspended in water. If it were possible, imagine a magnet held above this column at just such a position that the grains have no tendency to sink. In this case would the presence of the iron in the water have any power to force a grain of quartz, for example, up? Certainly not. Any non-magnetic substance which could sink in water could sink with the iron present. If, however, the magnet were removed, and a current of water passed up through the tube, just sufficient to keep the iron in suspension, it would be found that grains of quartz which might be able to sink through this current of water were the iron not present are now unable to penetrate this bed of teetering grains, and if they should get into it, it would be forced up again.

In the case of galena, or any other mineral, there is an action similar to that of the imaginary magnet, which keeps the grains from sinking as rapidly as we might expect. This action is the combination of all the forces described above as adhesion, cohesion, internal friction, etc. The power of the grain of galena to force up the larger grain of quartz is measured by its ability to sink. Thus the increase in the specific gravity of the teetering column due to the presence of teetering grains is not wholly available for keeping other grains from settling. The available increase of specific gravity is proportional to the available velocity of grains forming the teetering column. By the available velocity of a grain is meant the actual velocity in contrast to the theoretical velocity. On Plate V is shown what per cent. the available velocities of quartz and galena grains are to their theoretical velocities. It is seen that the actual velocities range from practically nothing for the smaller grains to 83 per cent. for the largest galena grains plotted there.

If these percentages be applied to the equations for the specific gravity of teetering columns as plotted on Plate VI, we get the other curves which show the effective specific gravities of these teetering columns under the conditions of full teeter and just teeter.

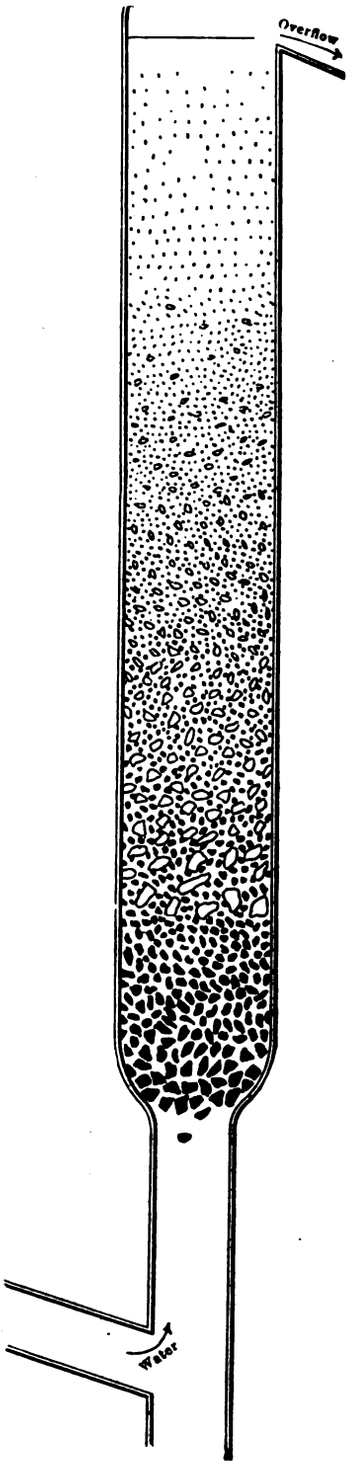

Fig. 1. Condition in Hindered Settling.

Equations for Hindered Settling

The general equation for the free-settling velocity of any mineral has been found. For hindered - settling the ony difference is that the specific gravity of the liquid, through which the grains are to fall, has been increased. Instead of its being unity it has become L_1, which varies with the size of the grains forming the teetering col-

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umn, and with the condition of teeter used, as potted on Plate VI. Thus we may write the general hindered-settling equation:

$$V = \sqrt{\frac{W\,(G - L_1)\,8g}{D^2 G\,3.1416}} - (0.1115 \sqrt{\frac{W\,(G - L_1)\,8g}{D^2 G\,3.1416}} \div D + 21.1)$$

or calling the term

$$\sqrt{\frac{W\,(G - L_1)\,8g}{D^3 G\,3.1416}} \div D, \text{ a};$$

$$V = 158 \sqrt{\frac{W\,(G - L_1)}{D^2 G}} - (0.1115a + 21.1).$$

For quartz, where $W = 1.15D^3$, the equation becomes:

$$V = 104 \sqrt{(G - L^1)\,D_q} - (0.1115a + 21.1),$$

$$\text{a being } 104 \sqrt{G - L_1}.$$

Consider the case of quartz and galena. For any value of V we find the corresponding size of the galena grain having that free-settling velocity, or vice versa. Thus where quartz is the lighter mineral the equation for hindered-settling becomes:

$$V = 104 \sqrt{(G - L^1)\,D_q} - (0.1115 \times 104 \sqrt{G - L_1} + 21.1).$$

From the size of the galena grain and the condition of teetering we wish to consider, we find the corresponding value of L_1 from Plate VI. All the terms of the above equation are now known except D_q. By solving the equation we get D_q corresponding to V and D_g, from which we can plot the hindered-settling velocities of quartz and galena corresponding to the conditions of teeter, as done in Plate VII.

In finding the specific gravity of a mixture of water and a mineral we can use the formula $L = (G - 1)\,P + 1$, where P is the proportion of the mixture occupied by the mineral. In the case of galena this becomes $L = 6.5\,P + 1$. For the condition of full teeter we have found that for grains under 0.6 mm. $L = 2 + 2.5\,D$, therefore

$2 + 2.5\,D = 6.5\,P + 1$; $P = \dfrac{1 + 2.5\,D}{6.5}$. Likewise for the condition of just teeter in the case of grains under 0.7 mm. $P = \dfrac{2 + 1.43\,D}{6.5}$. If P_w represents the proportion of the mixture occupied by water $P + P_w = 1$, or $P_w = 1 - P$.

Application to Classification

To figure the ratio of the size of the constriction to that of the tube containing the teetering column so that the velocity of water in both cases would be the same, let us call A the area of cross-section of the tube containing the teetering column and C that of the constriction. Then $\dfrac{C}{A} = P_w$.

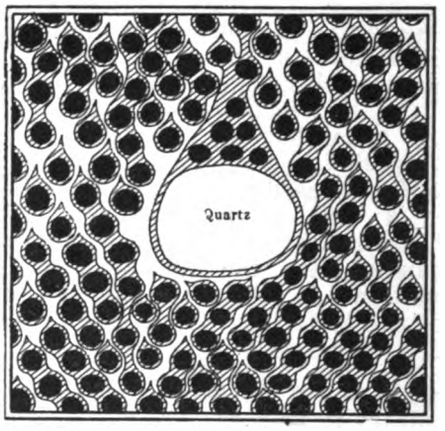

Fig. 2. Galena and Quartz Grains Showing Still Water.

Here again we find that the practical and the theoretical conditions do not match, so we must consider the working conditions. Fig. 2 represents a vertical section of a teetering column. The galena grains are represented in solid black. The areas cross-hatched represent water which is practically still. The unshaded spaces between the grains represent the portion of the water which is moving. For experiments it is found that in the case of full teeter, about half of the water has the effect of being still. For larger grains it is slightly more than half and for smaller ones less, but for practical purposes we may consider half of the water as moving and half as still for all size grains. Under this consideration our formula becomes

$$\frac{C}{A} = \frac{P_w}{2} = \frac{1 - P}{2} = \frac{6.5 - 1 - 2.5\,D}{13}$$

$$= \frac{5.5 - 2.5\,D}{13} = 0.423 - 0.192\,D,$$

where the teetering galena grains are below 0.6 mm. Where they are above that

$$L = 3.5;\ P = \frac{2.5}{6.5};\ \frac{C}{A} = \frac{1 - P}{2}$$

$$= \frac{6.5 - 2.5}{6.5 \times 2} = 0.308.$$

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In the case of just teeter the active water is more nearly a third of all the water and the ratio works out

$$\frac{C}{A} = \frac{1-P}{3} = \frac{6.5-2-1.43\,D}{6.5\times 3}$$

$$= \frac{4.5-1.43\,D}{19.5} = 0.231 - 0.073D.$$

Hindered Settling Classifying

From the equations for the ratio of size of constriction to that of teetering column it is seen that to maintain a given condition, such as full teeter, the apparatus used for every size grain must be different. The smaller the grain the smaller must be the ratio C to A, in the apparatus. If a tube, as in Fig. 1, is used and the current cut off by degrees we will have grains of galena and quartz coming down together which have the same hindered-settling ratios, but each time the condition of teeter will be different. If the ratio of size of constriction to teetering column is such that the larger grains are in a state of full teeter when the current is just enough so they cannot fall through the constriction, then by the time the smaller grains begin to come down a state of less teeter is maintained. The grains are not at full teeter, thus the specific gravity of the column is increased above what it would be if they were, and we are approaching the state of just teeter. Experiments carried out with such an apparatus have thus been known to give, within narrow limits, a higher hindered-settling ratio for the smaller grains than for the larger ones.

It may be difficult to change the ratio of size of constriction to size of teetering column as the size of grains changes, so an apparatus designed on the principle of Professor Richards' hindered-settling classifier may be of interest as it can be made to regulate this difficulty automatically. As shown in Fig. 3, there are a series of tubes through which a diminishing series of currents are rising. The currents are so regulated that the first tube will maintain a bed of galena of a desired size. The other tubes maintain beds of galena of decreasing size. In this way each tube is made of such a size, in proportion to that of the constriction, that the desired condition of teetering is maintained.

Suppose we are treating a product of galena and quartz below 2 mm. diameter, and decide to maintain the condition of full teeter, (this condition is higher than desirable in practice). We wish to get only galena in the first product. From Plate VII we see that if we use a current of 95 mm. per sec. in the constriction we will maintain a column of galena 0.22 mm. diameter and that the quartz which has an equal settling velocity with this is 9.6 times as large, i. e., is 2.11 mm. diameter. The ratio of cross-section of constriction to the upper tube is $0.423 - 0.192 \times 0.22 = 0.381$, and the ratio of their diameter is $\sqrt{0.381} = 0.617$.

In the second tube we wish to catch all quartz above 1.6 mm., for example. If we use a current in the constriction of 84 mm. per sec. we see from Plate VII that a column of galena 0.19 mm. in diameter will be maintained and quartz 8.4 times as large, or 1.60 mm. will have an equal settling velocity. Thus we will catch here quartz between 1.60 and 2 mm. and galena between 0.19 and 0.22 mm. The ratio of area of constriction to that of the upper tube is again figured to be $0.423 - 0.192 \times 0.19 = 0.387$ and the ratio of their diameters

$$\sqrt{0.387} = 0.623.$$

The same method of calculation can be applied to each tube.

In practice it may be well to have velocities slightly above those calculated, and the ratio C to A slightly larger because of the imperfect action of the teetering grains. By reason of their odd shapes they are constantly bobbing up and down. Unless this precaution is taken a grain at the bottom of the teetering column which, because of this bobbing effect, is moving down, is met by a rising current only sufficient to support it. The downward momentum of the grain may be enough to carry it through the constriction and it will be found that the size of the grains finally left in the teetering column is slightly below what we calculated on. The longer the constriction the less will this effect enter in.

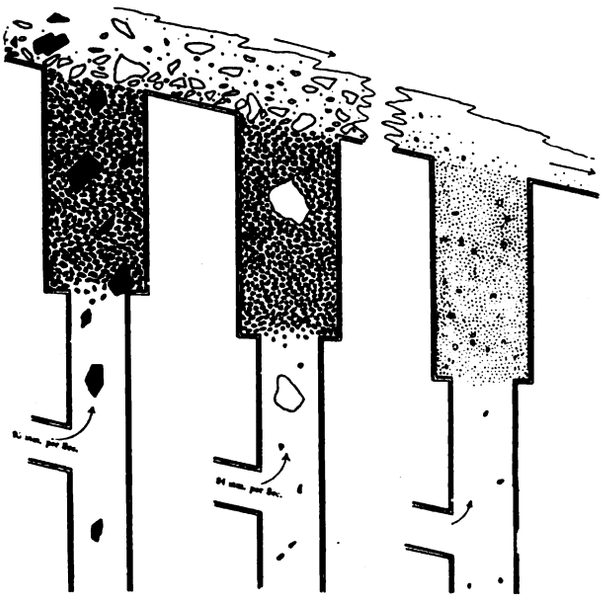

Fig. 3. Apparatus for Hindered Settling Classifying.

The object in hindered-settling is to effect a higher ratio in the sizes of the grains of the heavier and the lighter minerals than can be done by simple free-settling. This is accomplished by establishing a teetering column of the heavier mineral, which acts toward the lighter mineral as though it were a liquid of greater specific gravity than water, and at the same time allows the heavier mineral to act under free-settling conditions.

The efficiency of the system depends on how high an effective specific gravity can be maintained in the teetering column. This can be done by keeping as low a state of teeter as the efficient working of the apparatus will stand; and then by bringing the effective specific gravity of the column up as near as possible to the actual. This latter state can be helped by using for the teetering grains those approaching spheres; for spheres, having the same cross-section for all positions, can be made to teeter quietly, thus keeping the teetering column of even texture. Odd shaped grains, having widely different cross-sections, depending on the position they

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are in, will be either rising or sinking all the time. This constant movement of the grain spoils the effect of the column. It can be largely overcome, however, by lengthening the column. In a system as shown in Fig. 3, this difficulty soon remedies itself, for the more spherical grains will by degrees take the place of the odd-shaped ones, and in time the teetering column will be composed of all the most spherical grains of the size which just cannot sink in the constriction.

Where galena is to be separated in practice from a gangue it would greatly increase the efficiency of a hindered-settling classifier if columns of granulated lead were first established by running a lot of it through the system. In this way the specific gravity of the teetering column would be increased, and the spheres of lead could be depended on to teeter much more uniformly than the odd-shaped grains of galena which might happen to form the columns.

In the case of the finest grains the effective specific gravity of the columns can be increased by increasing the actual, as related to the theoretical, velocities of the grains. This can be done by using water charged with a salt, such as soda-alum, which, by breaking down the cohesion of the water, will allow these small grains to have a higher settling velocity.

Before a hindered-settling classifier, or other such apparatus, can be relied upon to give best results a thorough understanding of the laws of hindered-settling must be had and applied to the apparatus. Once this is done the hindered-settling apparatus is destined to supersede, in certain classes of work, the free-settling one; especially where fine results are desired, or minerals of nearly the same specific gravity are to be separated.

By following the procedure given above for galena and quartz, a typical ore and gangue, similar results can be worked out for any minerals; the only data required being an equation for the weight of the grains of the minerals in question in respect to their diameters. As yet not enough experimental work has been carried out to warrant any claim as to the ultimate accuracy of all the equations.

MILL DATA

Circulating Feed

To find total tonnage in a crushing element of a mill, when part of the load is returned from classifier or sizing screen, back to the beginning:

$$Q = \frac{100T}{100 - P}$$

Where

T = Initial Tonnage per day, feed and discharge from element.

P = % of oversize returned.

Q = Total Tonange per day through the element.

Example:

$$T = 100 \text{ tons}, \quad P = 75\% \quad Q = \frac{100 \times 100}{100 - 75}$$

$$= 400 \text{ tons.}$$

—General Engineering Co.

Recovery and Ratio of Concentration

Knowing the assay value of the Heads, Tails and concentrates.

$$R = \frac{C-T}{H-T}, \quad E = \frac{100\,C}{H\,R}, \quad E = \frac{100\,C \times (H-T)}{H \times (C-T)}$$

Where

H = heads assay, T = tailing assay, C = Concentrates assay,

R = ratio of concentration (tons in one,)

E = recovery in %.

Example:

Heads, 2.4% Pb; Tails, 0.95% Pb; Concentrates, 11.95% Pb.

$$R = \frac{11.9 - 0.95}{2.4 - 0.95} = \frac{10.95}{1.45} = 7.56, \text{ Ratio of Concentration.}$$

$$E = \frac{11.9 \times 100}{2.4 \times 7.56} = \frac{11.90}{18.15} = 65.6\%, \text{ Recovery.}$$

—General Engineering Co.

LAUNDER DATA, CANANEA CONSOLIDATED*

In the accompanying table is given information concerning the launder system installed at the concentrating plant of the Cananea Consolidated Copper Co., Cananea, Sonora, Mexico. This should prove useful as a guide to those having to install launders where it is impossible to make preliminary tests. In order that comparison may be made the character of the ore handled is also given.

The country rock in which the copper ores are found is principally diorite. The remainder of the ore is obtained from deposits in limestone, quartzite and quartz porphyry. The principal minerals in the concentrating ore are pyrite, chalcopyrite, bornite, chalcocite, native copper, garnet, sphalerite, galena and oxides and carbonates of copper.

*Eng. and Min. Journal.

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LAUNDER DATA, CANANEA CONSOLIDATED COPPER CO.

Material Handled	Size of Launder Inches Depth Width	Grade in. per ft.	Lining	Ratio Solids: Liquids	Largest Particle mm.	% Wt. on 60 Mesh
Original feed to Section "C"	10 x12	3½	C.I.—11¼"	1:1	30.0	82.0
Bull jig tails, to coarse rolls	10 x 9½	3	C.I.— 9¼"	1:1.1	28.0	98.0
Roll jig tails, to fine rolls	10 x 7½	2¼	C.I.— 7¼"	1:3	10.0	98.0
Coarse jig concentrates	10 x 7½	1⅔	C.I.— 7¼"	1:2.9	35.0	95.0*
Undersize 2 mm. trommel to classifier	10 x 5¾	1½	C.I.— 5¼"	1:4.4	4.0	52.0*
1st spigot of classifier to sand jig	8 x 5¾	3⅓	C.I.— 5¼"	1:1.5	4.0	90.0
Shaking launder† for sand jig concentrates	6½x12	⅜	None—corners	1:19.0	4.0	84.0
Fine jig concentrates from shaking launder	10 x 7½	1 13/16	C.I.— 7¼"	1:6.0	4.0	80.0
Bryan (Chile) mill discharge to drag belt	8¾x11½	⅛	None—corners	1:1.7	2.5	26.0
Drag belt sands to classifier distributor	10 x 7½	1⅔	C.I.— 7¼"	1:0.9	2.5	46.0
No. 1 spigot of classifier to mud jigs	8 x 5½	1⅜	C.I.— 5¼"	1:17.0	3.0	60.0
Table feed, tables 27 to 30	7¼x 5½	½	None—corners	1:8.4	1.0	0.8
Table concentrates, drag belt launder‡	9½x 9½	⅛	1½" boards	1:26.0	1.0	18.6
Table concentrates, shaking launder§	4 x 7½	3/32	None—corners	1:7.4	0.5	35.2
Slimes, section "C", settling tanks to Section "B" vanners	6½x 9½	3/16	None	1:96.0	0.17	0.0
Slime feed to vanners, Section "C"	9½x11½	⅓	None	1:4.7	0.17	0.5
Vanner concentrates, drag belt launder‖	10x25x16	Level	None	1:31.0	0.2	1.0
Vanner and table concentrates	6½x 6	1 13/16	None	1:20.0	2.0	27.2
Vanner tails, Section "C"	9½x11½	⅓	None—corners	1:7.0	0.4	0.4
Coarse tails, table and jig	9½x22	⅓	½" boards & corners**	1:27.0	2.0	41.6*
Coarse sand tailings to dam No. 2	12¼x11½	11/32	½" boards & corners**	1:21.0	2.0	19.5*
Coarse sand tailings to dam No. 1	12 x11	3/32	½" boards & corners**	1:21.0	2.0	19.6*
Slimes to mill No. 4	9½x12½	¼	None—corners	1:4.4	0.1	0.0
Sands and slimes to mill No. 3	10 x11½	¼	None—corners	1:5.0	1.5	2.6
Feed to vanners, mill No. 4	6 x 7½	½	None	1:4.4	0.1	0.0
Slime concentrates, mill No. 4, drag belt launder	12x24x18	Level	None‡		0.1	0.2
Slime concentrates, mill No. 4, elevator to bins	7 x 7½	⅔	Glass—corners††	1:20.0	0.1	0.4
Slime concentrates, mill No. 3, elevator to bins	10 x12	13/16	Concrete	1:8.7	0.2	2.8
Slime tails, mill No. 4, to mill No. 3 settling tanks	10 x11	7/32	None—corners	1:6.3	0.1	0.0

All cast-iron liners have 2-in. effective depth and 24-in. length, with corners rounded.

*Liable to choke. †Speed 160 r.p.m., actuated by heavy head motion. "Corners" are strips of wood with cross-section of 45° triangle nailed in corners of launder. ‡Speed 75 ft. per min.; old 4-in. drive belts are used, no scrapers. §Speed 180 r.p.m. ¶Effective width 6 in. ‖Speed 75 ft. per min. **Boards laid with grain across direction of flow. ††Glass liners, ¾x4x14 in.

The accompanying anaysis of crude ore represent the typical sliming and nonsliming ores. Although so different in physical characteristics as regards slime-forming qualities, their chemical composition is remarkably similar.

ANALYSES OF CRUDE ORE AND TAILING AT CANANEA CONSOLIDATED CONCENTRATOR

	Copper %	Silica %	Alumina %	Iron %	Lime %	Sulphur %
Crude ore:						
Maximum slimes, rock decomposed	2.42	51.0	14.3	10.8	1.2	10.5
Minimum slimes, rock hard	1.50	57.0	12.7	6.2	1.0	6.6
Concentration tailing:						
Coarse tails, to No. 2 dam	0.72	67.6	17.5	1.8	1.2	1.4
Slimes to No. 4 mill	1.02	76.6	11.3	2.2	1.0	4.0

The concentrates assay approximately 6.86% Cu, 18.6% insoluble, 31.5% iron, 36.2% sulphur. The composition of the tailing after concentration is shown in one of the accompanying tables. The specific gravity of the pyrite is 4.84 and of the chalcopyrite, 4.17. The coarse sands have a specific gravity of 2.7 and the fine slimes, 2.8. Thanks are due to F. J. Strachan, superintendent of the plant, for permission to publish the above data.

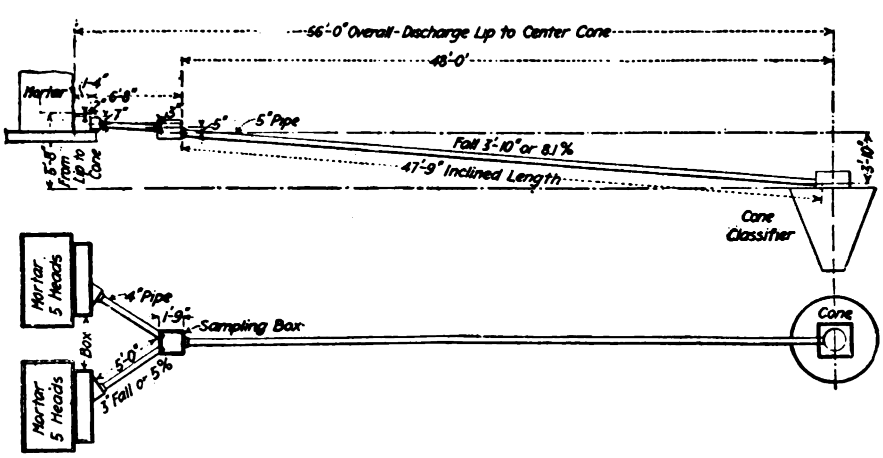
GRADE OF DISCHARGE PIPES*

Little authentic data is published respecting the grade of launders, or pipes, since the introduction of coarse-crushed material as tube-mill feed. In the example in the accompanying illustration, the product from a screen with 9 holes per sq. in., quartz in schist, was as follows:

Mesh	+20	+40	+80	+100	—100
%	35.5	17.0	12.1	5.4	30

This sizing shows roughly one-third each of coarse, middling and fine product. The water ratio in this instance was 6 to 1. The denser the pulp, the more readily is the coarse product kept in suspension, and in consequence the pulp flows more freely and requires less grade.

An ideal section for a coarse-pulp conveying pipe would be an oblong or flattened section, affording the rolling action of the coarse particles increased surface. A round ppe, however, is readily procurable and has the advantage of being capable of being turned twice through 120°, affording three surfaces to abrasion. It is important that the pipe be proportioned to the volume of the pulp, neither too large nor too small. A launder has the approved section, but necessitates additional grade, a most essential consideration at times.



Grade for Pulp Flow.

*Eng. and Min. Journal.

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The sketch shows, by repeated trial, the minimum grade of pipe that will successfully convey coarse ore particles. The specific gravity of the ore is 2.8 and the pulp half fills the pipe at the entrance.

It is important to maintain the pipe on a uniform grade, and to guard against obstructions on the lower inside surface, such as a projecting gasket or coarse extraneous material.

A rod, 3/8 in. in diameter, connected by links, inserted into the pipe, assists, by occasional working, in keeping the pipe clear of obstructions.

The sampling box is a commendable feature of this pipe arrangement, though it sacrifices some inches of elevation. The smaller 4-in. pipe works with a 5% grade. It is suggested, therefore, that for the conveying of coarse ore particles from the mortar, a gradient of not less than 10% be allowed, measured from the mortar lip to the classifier, with 2 ft. additional for contingencies.

Slope of Launders

The accompanying table, containing data concerning the fall of launders for different classes of material, is taken from a description of the mill at the Lucky Tiger mine, El Tigre, Sonora, Mex., by D. L. H. Forbes (Bull., A. I. M. E., August, 1912.) Anyone who has been called upon to design a launder system will appreciate the practical value of this sort of information.

LAUNDER FALLS USED IN NO. 2 MILL OF THE LUCKY TIGER MINE

Situation	Size		Dilution of Pulp S:L	Fall Per Foot
	Width	Height		
	In.	In.		In.
Stamps to classifier	8	8	1:6	7/8
Classified coarse sand to Wilfleys	6	6	1:3	7/8
Classified fine sand to Wilfleys	6	6	1:3	3/4
Slime to dewatering tanks	8	8	1:20	1/8
Thickened slime to Deister tables	6	6	1:4	5/8
Sand tailings from Wilfley tables	8	8	1:5	1
Middlings from Wilfleys to pan	4	4	1:3	1
Concentrates from Wilfleys to bin	4	6	....	1 3/4
Slime tailings from Deister tables	6	6	1:7	5/8
Middlings from Deisters to 4th table	4	4	1:4	5/8
Concentrates from Deisters	4	6	....	1 1/8

SLOPE FOR LAUNDERS

Size of Material	Degrees	Slopes, In. per Ft.	Condition
Mine or to breaker	36° 35′	8.9	Dry
2 in. to 1 in.	37° 50′	9.33	Wet
1 in. to 1/2 in.	33° 40′	8.0	Wet
1/2 in. to 1/4 in.	29° 5′	6.66	Wet
1/4 in. to 1/8 in.	24° 0′	5.33	Wet
1/8 in. to 1/16 in.	18° 25′	4.0	Wet
1/16 to vanner material	7° 33′	1.6	Wet
Vanner or table material	6° 20′	1.33	Wet
Tail race for 1/16 in. material	3° 35′	0.75	Wet
Tail race for 1/8 in. or larger	6° 20′	1.33	Wet
Trommel casing for + 1/2 in. material	33° 40′	8.0	Wet
Trommel casing for — 1/2 in. material	16° 15′	3.5	Wet

Eng. and Min. Journal.

CONCENTRATION CALCULATIONS

It frequently happens that some idea is desired as to what recovery is being secured in tests or in milling operations when it is not possible to get the weights of the products. The following formulas are believed to be absolutely sound in theory, but it should never for a minute be lost sight of that they are founded on the following assumptions:

(1) That the samples taken represent, without any error whatever, the average of the material.

(2) That the assays of the samples are absolutely correct.

Ratio of Concentration and Recovery

Having granted the two above assumptions, we can combine and transform certain symbols and get expressions for percentage of recovery and ratio of concentration which contain only the known quantities, to wit: Assay of ore, assay of tailings, and assay of concentrates.

Let H = weight of ore in tons
C = weight of concentrates in tons
T = weight of tailing in tons
h = assay of ore
c = assay of concentrates
t = assay of tailings
R = ratio of concentration.

$$\text{Then } R = \frac{H}{C} = \frac{c-t}{h-t} \text{ (for assays alone)}$$

$$\text{Recovery} = \frac{C \times c}{H \times h} = \frac{c(h-t)}{h(c-t)} \text{ (for assays alone)}$$

$$\text{Per cent. Recovery} = \frac{100\,c(h-t)}{h(c-t)}$$

It cannot be urged too strongly that the above formulas must be used with caution. When actual milling operations are being carried on and the weights of ore and concentrates are taken daily, and where there are smelter returns to be used as a check, these formulas are useful as a check on samplers and assayers.

In small tests where careful hand samples are taken by several persons at different points in the concentrating scheme, and taken in different ways, I have acquired sufficient confidence in the formulas to use them as guides in planning work; but ultimately all the results must be checked by actual weights of products. If the samples are taken and assayed with care, the recovery by weights in nearly all cases has checked with the theoretical recovery as deduced by the formulas.

Errors Which May Affect Results

An investigation of the effect of certain errors is instructive. Assume first a fixed error in sampling and assaying which we shall call n per cent. too high. Then, by the formulas, per cent. of recovery =

$$100\left[\frac{(c+nc)\ (h+nh-t+nt)}{(h+nh)\ (c+nc-t+nt)}\right]$$

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or

$$100\left[\frac{c(1+n)\,[h(1+n)-t(1+n)]}{h(1+n)\,[c(1+n)-t(1+n)]}\right]$$

But 1+n cancels out, and it is evident that a constant error does not affect the result. This, however, is a condition of affairs that rarely holds in actual practice.

More often the condition will be somewhat as follows, though not often would the errors be so large:

(1) Sample A taken by trier out of trucks; error of, say, 1 per cent. too high.

(2) Sample B taken by tip sampler at flume at end of mill; error of, say, 2 per cent. too low.

(3) Sample C taken by trier out of trucks from concentrates bin; error of, say, 2 per cent. too high.

(4) Assays of A, B and C made volumetrically by a man who does not reach the end point of his titration by say 0.1 cc. This error, for convenience, we shall say is 3 per cent. too low on ore, 10 per cent. too low on tailings, and 1 per cent. too low on concentrates.

Applying these erroneous values in our formula, we have the percentage of recovery as follows:

$$\text{Recovery} = 100\left[\frac{\left(c+\frac{2c}{100}-\frac{c}{100}\right)}{\left(h+\frac{h}{100}-\frac{3h}{100}\right)}\times\frac{\left(h+\frac{h}{100}-\frac{3h}{100}-\frac{2t}{100}-\frac{10t}{100}\right)}{\left(c+\frac{2c}{100}-\frac{c}{100}-\frac{2t}{100}-\frac{10t}{100}\right)}\right]$$

Simplifying, we have

$$\text{Recovery} = 100\left[\frac{c\left(h-\frac{88}{98}t\right)}{h\left(c-\frac{88}{101}t\right)}\right]$$

Now, if the true values are: Ore, 3 per cent.; tailings, 1 per cent.; and concentrates, 12 per cent., the real theoretical recovery would be 72.7 per cent., but the erroneous assay values secured in the above sample the theoretical recovery seems to be 75.3 per cent.

As large errors were assumed in sampling and assaying, much larger, in fact, than any engineer would be inclined to admit possible in his case, what shall we say of those cases where the discrepancy in actual operations between the theoretical recovery and actual recovery is much greater than the difference between 72.7 per cent. and 75.3 per cent. and generally in the opposite direction? It is quite a common thing for engineers to belittle recoveries based on theory, and in order to see just what this means let us take another case not more radical in its assumptions than many within the knowledge of most engineers.

For this purpose I shall define three terms:

(1) **The real theoretical recovery.** By this I mean the unattainable figure which would take into account every atom and molecule; this figure no one ever knows, but we try to get at it approximately by our samples and analyses.

(2) **The apparent theoretical recovery.** This is based on applying the above formulas to the figures we have secured by sample and assays as representing the value of ore, tailings and concentrates. As shown above it takes a large strain on our credulity to allow the apparent theoretical recovery to exceed the real theoretical recovery by 2.6 units.

(3) **The actual recovery.** This is shown on the books of the mine by the assays and weights of the products. This amounts in known cases to as much as 10 per cent. below the theoretical recovery.

Having defined the terms we shall assume: Real theoretical recovery, 75 per cent.; apparent theoretical recovery, 77.5 per cent.; and actual recovery, 67.5 per cent. As we already strained our credulity in the interpolation of sampling and assaying errors, we must look elsewhere for an explanation of an error of 7½ units.

There are probably **three chances of error** which are independent of and do not contribute to the vitiation of samples and assays:

(1) **Errors of moisture determination.** Moisture determinations can, with proper care, be easily and accurately made. The error, which is often a large one, comes in the sampling rather than in the determination of the moisture in the sample; ores of wet clayey mines and wet concentrates will be too low. Conversely, if the moisture is reported lower than the truth, the recovery as derived from the assay and weight of concentrates will be too high. A consideration of the various methods of taking samples of wet concentrates for moisture leads one to believe the commonest error is to report the moisture in concentrates too high, and so the actual recovery as calculated on this basis is generally too low.

(2) **Errors in weight.** There should be little error in this regard, but the tare of trucks and wagons is often assumed from one weighing and no alteration ever made for wet or muddy weather or lost parts. In a recent case on a famous mine the error in weight due to a dishonest employee was an increase of 40 to 50 tons per day reported on the weight of the ore, amounting to an error of 20 per cent. The most common case of error in weights is on the side of giving good measure.

(3) **Losses in handling.** These may be, and often are, great. Concentrates shipped to Europe in bulk may shrink 5 per cent. in weight, or concentrates stored in heaps in the open may shrink rapidly, due to the wind. These two losses, however, should be taken into account when one is calculating the actual recovery.

In a mill itself there is a daily accumulation of spills which are often hosed or sluiced through the floor; millmen are generally careful not to allow this material to get into the tailings sampler.

Having briefly reviewed the possible errors, the apparent theoretical recovery and actual recovery in the case taken for illustration appear somewhat

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as follows: Apparent theoretical recovery, 77.5 per cent.; actual recovery, 67.5; errors in assaying and sampling, 2.5; errors in moisture determination, 1.5; errors in weight, 2; losses in handling, 4. Attention to the details of each of these operations will always serve to reduce the gap between the theoretical and actual recovery, and it behooves an engineer to get the gap closed rather than to take the complacent attitude that "the theoretical recovery is always too high."

Formulas for Circulating Load, Screen Feed and Screening Efficiency

Let a = Per cent. excess on given mesh in screen feed
b = Per cent. excess on given mesh in screen oversize
c = Tonnage milled = screen product
d = (100-a) = Per cent. throughs in screen feed
e = (100-b) = Per cent. throughs in screen oversize
x = Tons of screen feed
y = Tons of screen oversize
E = Screen efficiency
C = Circulating Load.

$$\text{Then Circulating Load} = \frac{ac}{b-a}$$

$$\text{Screen Feed} = \frac{bc}{b-a}$$

$$\text{Screen Efficiency} = 1 - \frac{ea}{db}$$

Formulas for Determining Garfield Table Products, When Only Part Are Known

Also suitable for any other device where but concentrates and tails are made.

Use same designations as under Ratio of Concentration and Recovery.

$$\text{Then } C = \frac{Hh - Tt}{c} = \text{weight of concentrates}$$

or if tailings are not known

$$C = \frac{H(h-t)}{(c-t)}$$

And H — C = T = tons of tailings.

Formulas for Wilfley Table Middlings and Concentrates

Also suitable for other cases where a concentrate, middling and tailing are made.

Use same designations as in last example.

Also let M = Weight of middlings in tons.
m = assay of middlings.

$$\text{Then } M = \frac{H(c-h) + T(t-c)}{(c-m)}$$

$$C = \frac{H(h-m) + T(m-t)}{(c-m)}$$

Slime Formulas

When S = Specific gravity of dry slime.
x = Specific gravity of slime pulp
y = Per cent. (by weight) of dry slime in pulp.
62.5 lbs. in 1 cu. ft. of water
32 cu. ft. water = 1 ton of water.

$$\text{Then, } x = \frac{\text{weight of pulp}}{\text{weight of an equal volume of water}}$$

$$S = \frac{\text{weight of dry slime in air}}{\text{weight in air} - \text{weight in water}}$$

$$= \frac{xy}{xy - 100(x-1)}$$

Also,

$$\text{Per cent. (by weight) of dry slime in pulp} = \frac{100\,S(x-1)}{x(S-1)}$$

$$\text{Per cent. (by weight) of solution in pulp} = \frac{100(S-x)}{x(S-1)}$$

$$\text{Ratio (by weight) of solution to 1 of dry slime} = \frac{S-x}{S(x-1)}$$

$$\text{Volume in 1 cu. ft. of one ton pulp} = \frac{32}{x}$$

$$\text{Weight (in lbs.) of 1 cu. ft. of pulp} = \frac{2000\,x}{32}$$

$$\text{Weight (in lbs.) of dry slime in 1 cu. ft. of pulp} = \frac{62.5\,S(x-1)}{(S-1)}$$

$$\text{Volume in cu. ft. of pulp containing 1 ton of dry slime} = \frac{32(S-1)}{S(x-1)}$$

$$\text{Weight in tons of dry slime in charge of 1 cu. ft. of pulp} = \frac{S(x-1)}{32(S-1)}$$

Formula for Settling Tank Overflow and Discharge

Also adaptable to calculating unknown quantities in a hydraulic classifier, when the water injected contains a known per cent. solids by considering discharge, as spigot product and hydraulic added as a portion of the feed to tank.

Let a = Tons of tank feed
b = Per cent. solids in feed
c = Per cent. solids in the discharge
d = Per cent. solids in overflow
x = Tons discharge (total) through spigot
y = Tons overflow (total)

$$\text{Then } x = \frac{a(b-d)}{(c+d)} = \text{tons discharged}$$

$$y = \frac{a(c-b)}{(c+d)} = \text{tons overflow.}$$

Compiled from T. J. Hoover's Paper in Eng. and Min. Journal, and original notes.

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MISCELLANEOUS ORE-DRESSING DATA

SPECIFIC GRAVITY OF THE MORE IMPORTANT MINERALS, COMPILED FROM DANA'S MINERALOGY

Native Elements

	Sp. Gr.		
Graphite	2.09	to	2.23
Antimony	6.65		6.72
Bismuth	9.70		9.83
Gold	15.6		19.3
Silver	10.1		11.1
Copper	8.8		8.9
Mercury	13.596		
Platinum	14.		19.
Iron	7.3		7.8

Sulphides of the Semi-Metals

	Sp. Gr.		
Stibnite; Gray Antimony	4.52	to	4.62
Bismuthinite; Bismuth Glance	6.4		6.5
Molybdenite; Molybdenum Disulphide	4.7		4.8

Sulphides, Selenides, Tellurides, Arsenides, Antimonides of the Metals

	Sp. Gr.		
Galena; Lead Glance	7.4	to	7.6
Argentite; Silver Glance	7.2		7.36
Petzite; Gold and Silver Telluride	8.7		9.02
Hessite; Silver Telluride	8.31		8.45
Chalcocite; Copper Glance	5.5		5.8
Sphalerite; Zinc Blende	3.9		4.1
Coloradoite; Telluride Mercury	8.6		
Cinnabar; Mercury Sulphide	8.		8.2
Millerite; Nickel Sulphide	5.3		5.65
Niccolite; Copper Nickel	7.33		7.67
Pyrite; Iron Pyrites	4.58		4.64
Marcasite; White Iron Pyrites	4.9		5.4
Arsenopyrite; Mispickel	4.1		4.3
Sylvanite; Telluride of Gold and Silver	4.95		5.10
Krennerite; Telluride of Gold and Silver	4.85		4.9
Chalcopyrite; Copper Pyrites	5.9		6.2
Bornite; Purple Copper Ore	7.9		8.3
Pyrrhotite; Magnetic Pyrites	8.35		
Calaverite; Telluride of Gold and Silver	9.04		

Sulpho-Salts

	Sp. Gr.		
Zinkenite	5.3	to	5.35
Bournonite; Wheel Ore	5.7		5.9
Pyrargyrite; Ruby Silver; dark red	5.77		5.86
Pyroustite; Ruby Silver; light red	5.57		5.64
Tetrahedrite; Gray Copper	4.4		5.1
Tennantite	4.37		4.49
Polybasite	6.		6.2
Stannite; Tin Pyrites	4.3		4.52

Chlorides, Fluorides

	Sp. Gr.		
Calomel; Horn Quicksilver	6.48		
Fluorite; Fluor Spar	3.01	to	3.25
Cryolite; Fluoride or Sodium and Aluminum	2.95		3.

Oxides

	Sp. Gr.		
Quartz; Silica	2.65	to	2.66
Tridymite; Pure Silica	2.28		2.33
Opal	1.9		2.3
Cuprite; Red Copper	5.85		6.15
Zincite; Red Oxide of Zinc	5.43		5.7
Corundum; Alumina	3.95		4.10
Hematite; Iron Sesquioxide	4.9		5.3
Magnetite; Magnetic Iron Ore	5.16		5.18
Franklinite	5.07		5.22
Chromite	4.32		4.57
Cassiterite; Tin Ore	6.8		7.1
Manganite	4.2		4.4
Bauxite	2.55		
Limonite: Brown Hematite	3.6		4.

Carbonates

	Sp. Gr.		
Calcite; Calc. Spar; Calcium Carbonate	2.71		
Dolomite; Carbonate Calcium and Magnesium	2.8	to	2.9
Magnesite; Magnesium Carbonate	3.		3.12
Siderite; Spathic Iron	3.83		3.88
Rhodochrosite; Manganese Protocarbonate	3.45		3.60
Smithsonite; Zinc Carbonate	4.30		4.45
Aragonite; Calcium Carbonate	2.93		2.95
Witherite; Barium Carbonate	4.27		4.35
Strontianite; Strontium Carbonate	3.68		3.71
Cerussite; White Lead Ore; Lead Carbonate	6.46		6.57
Malachite; Cupric Carbonate; Basic	3.9		4.03
Azurite; Cupric Carbonate; Basic	3.77		3.83

Silicates

	Sp. Gr.		
Amphibole; Horn Blende	2.9	to	3.4
Beryl	2.63		2.80
Garnet	3.15		4.3
Willemite	3.89		4.8
Chrysolite	3.27		3.37
Muscovite; Common Mica	2.76		3.
Serpentine; Magnesium Silicate	2.50		2.65
Talc	2.7		2.8
Kaolinite; Kaolin	2.6		2.63

Sulphates

	Sp. Gr.		
Barite; Heavy Spar	4.3	to	4.5
Anglesite; Lead Sulphate	6.3		6.39
Crocoite; Lead Chromate	5.9		6.1

Tungstates

	Sp. Gr.		
Wolframite; Wolfram	7.2	to	7.5

SCALE OF HARDNESS (MOHS)

Agate	7.0	Gypsum	2.0
Alabaster	1.7	Heavy spar	3.3
Alum	2.0–2.5	Hornblende	5.5
Amber	2.0–2.5	Iridium	6.0
Andalusite	7.5	Jasper	7.0
Anthracite	2.2	Kaolin	1.0
Antimony	3.3	Lead	1.5
Apatite	5.0	Meerschaum	2.0–3.0
Aragonite	3.5	Mica	2.5–3.0
Arsenic	3.5	Nickel	5.0–5.5
Asphalt	1.0–2.0	Onyx	7.0
Augite	6.0	Opal	4.0–6.0
Beryl	7.8	Palladium	4.8
Bismuth	2.5	Platinum	4.3
Calamine	5.0	Quartz	7.0
Calcite	3.0	Ruby	9.0
Copper	2.5–3.0	Saltpeter	2.0
Copperas	2.0	Sapphire	9.0
Copper sulphate	2.5	Serpentine	3.0–4.0
Corundum	9.0	Silver	2.5–3.0
Diamond	10.0	Spinel	8.0
Dolomite	3.5–4.0	Stibnite	2.0
Emery	9.0	Sulphur	1.5–2.5
Feldspar	6.0	Talc	1.0
Fluorite	4.0	Topaz	8.0
Gold	2.5–3.0	Tin	2.0–3.0
Granite	7.0	Zinc	4.0
Graphite	0.5–1.0		

WEIGHT OF ROCK AND SAND*

Material	Cu. Ft. per Ton	Weight in Lbs. per Cu. Ft.
Sulphide ore in place	11 to 13	154 to 182
Sulphide ore broken	15 to 18	111 to 133
Oxidized ore in place	14 to 18	111 to 143
Oxidized ore broken	22 to 24	81 to 91
Quartz in place (sp. gr. 2.64)	12.0	165.0
Quartz broken	21.0	94.0
Earth in bank	18.0	111.0
Earth, dry and loose	27.0	74.0
Clay	17.0	118.0
Loose sand	25.0	80.0
Mill Tailing (sp. gr. 2.7)		
Sand collected under water	21.5	93.0
Transferred sand (before leaching)	26.0	77.0
Leached sand (after leaching)	24.0	83.3

*Richards Ore Dressing.

MISCELLANEOUS FIGURES ON THE WEIGHT OF BROKEN ORE*

Material	Cu. Ft. per Ton	Weight in Lbs. per Cu. Ft.
Mine ore coming to Mill, North Star Mining Company, California	20.0	100.0
Tailings of Mill, Calumet & Hecla Mining Company, Michigan	20.0	100.0
"Blue ground" (altered peridotite) as it comes from Kimberly Mines	20.0	100.0
Broken quartz as it comes from the Jumpers' Deep Mine, South A	20.8	96.0
Material from gravity stamps	23.0	87.0
Broken quartz conglomerate as it comes from Ferreira Mine	21.1	95.0
Material from gravity stamps, with the slimes removed	26.0	77.0
Quartz stamped dry through 40 mesh and charged dry into vats at the Victoria Mill, Hauraki Peninsula, New Zealand	26.6	75.0

*Richards Ore Dressing.

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WATER

The amount of water required per ton of ore treated will average about 700 gallons, inclusive of the water used for steam power. In poorly constructed mills this often runs up to 1,000 or 2,000 gallons per ton treated. If settling tanks are provided, and the water is allowed to settle, and then pumped back and used over, this amount per ton can be reduced to 200 gallons, or with a loss of 25%.

Each boiler requires from 5 to 7½ gallons per horse power per hour.

Each stamp requires from 60 to 80 gallons per hour.

Each 4-foot Chile Mill requires 300 to 750 gallons per hour.

Each 5-foot Chile Mill requires from 400 to 1,000 gallons per hour.

Each 5-foot Pan requires from 100 to 140 gallons per hour.

Each 8-foot Settler requires from 60 to 100 gallons per hour.

Each 6-foot Johnston Concentrator requires from 200 to 300 gallons per hour.

Stamps and Pulverizers

For each 800 to 1,000 lb. stamps from 3 to 6 gallons per minute per stamp. On medium hard ores with 1,000 lb. stamps crushing to 20 mesh, 5 tons per stamp with 3.5 to 4 gallons per minute is good work. This equals a pulp of from 4-5 to 1. Chilian and Huntington mills on similar ore will require a total of 5-6 tons of water per ton of ore passing the screens.

Jigs

For each 18x36 in. compartment of Harz Jigs treating:

1½ to 2½ mm. particles	2 to 4 gals. per min.
3½ to 5 mm. particles	5 to 7 gals. per min.
7 to 10 mm. particles	8 to 14 gals. per min.
15 to 20 mm. particles	21 to 28 gals. per min.

This is in addition to the water in the feed which can be assumed to be not less than 1:1 water and ore.

Revolving Screens (Spray Water)

Each 36x72 screen will require:

1½ to 3½ mm. holes	15 to 25 gals. per min.
3½ to 7 mm. holes	10 to 15 gals. per min.
7 to 15 mm. holes	5 to 8 gals. per min.

Callow T. B. Screens (24 in. Duplex)

Water in pulp 3½ to 4 tons water per ton dry feed.

Undersize spray 6 to 10 gals. per min.

Oversize spray 8 to 12 gals. per min.

Wilfley Tables

5 to 10 gals. per min.

Six-Foot Frue Vanners

1½ to 3 gals. per min.

Hydraulic Classifiers

A very variable quantity. Richards gives from 10 to 50 tons water per ton pulp or an average of 20 tons for all the mills visited by him.

Total Quantity of Water Required per Ton of Ore Treated in Different Kinds of Mills

Stamps and Vanners—20 to 30 mesh—4 to 6 tons.

Coarse Concentration—Rolls, Jigs and Tables—15 to 20 tons.

Combination Mills, Stamps, Vanners and Pans—6 to 8 tons.

Cyanide Mills, Shoveling Tails and Filtering Pressing—0.2 to 0.35 tons.

Cyanide Mills, Sluicing Tailings—1.3 to 1.9 tons.

This is without water for boilers and no pumping back. With settling tanks or ponds it is safe figuring to say that 50 to 60 per cent of the original water (in all but mills shoveling tailings) is available for use over again and that with automatically discharging tanks for sands and decantation tanks for slimes, 75 to 80 per cent of the gross quantity used can be recovered.

Water Required for Steam Engines per Indicated H P.

Non-Condensing Engines=0.05 to 0.066 gals. per min.

Condensing Engines=0.04 to 0.05 gals. per min.

Compound Condensing Engines=0.025 to 0.4 gals. per min.

U. S. gals. per min. x 500=Pounds of steam per hour.

A "Boiler" Horsepower=30 lbs. water evaporated per hour.
=10 sq. ft. heating surface.
=½ sq. ft. grate area
=13 sq. in. flue area.
= 6 sq. in. smoke stack area.

General Engineering Bulletin.

POWER REQUIRED FOR VARIOUS MACHINES*

*Approximate only; taken from General Engineering Bulletin.

Crushers—BLAKE—7x10, 8 h.p.; 9x15, 15 h.p.; 10x20, 20 h.p.; 15x24, 30 h.p.
DODGE—4x6, 2 h.p.; 7x10, 7 h.p.; 11x15, 15 h.p.
GATES—D Style No. 1, 10 h.p.; No. 2, 15 h.p.; No. 3, 25 h.p.; No. 4, 30 h.p.; No. 5, 40 h.p.; No. 6, 60 h.p.; No. 7, 125 h.p.; No. 8, 150 h.p.

Mills—10-stamp, 90 8 in. drops per minute, 750 lb., 15 h.p.; 850-lb., 17 h.p.; 950-lb., 19 h.p.; 1,000-lb., 20 h.p.
TUBES—5x14-ft., 30 h. p.; 5x22-ft., 70 h.p.; 4x20-ft., 50 h.p.
CHILIAN—4-ft., 6 h.p.; 5-ft., 12 h.p.; 6-ft., 25 h.p.
HUNTINGTON—3½-ft., 4—5 h.p.; 5-ft., 6—7 h.p.; 6-ft., 8—10 h.p.

Rolls—CORNISH—12x20, 12 h.p.; 14x27, 16 h.p.; 16x36, 25 h.p.

Sample Grinders—No. 1, 3 h.p.; No. 2, 4 h.p.

Amalgamating Pans—5-ft., 4 h.p.; 8-ft., 6 h.p.

Grinding Pans—5-ft., 6 h.p.; 8-ft., 9 h.p.

Settlers—8-ft., 3 h.p. **Agitators**—8-ft., 3 h.p.

Clean-Up Pans—48-in., 1½ h.p.

Hendryx Agitator—5 h.p.

Revolving Screens—½ h.p. **Revolving Dryers**—5 h.p.

Wilfley Tables—¾ h.p. **Frue Vanners**—½ h.p.

Hancock Jigs—5 h.p. **Harz Jigs**—(per compt.) 1 h.p.

Horsepower per Ton of Ore Treated per Day in Different Kinds of Mills

Stamps and Vanners—20—40 mesh, 0.75—1.0.

Coarse Concentration—10—20 mesh, 0.5—0.8.

Combination Stamp Mills—16—30 mesh, 1.5—1.75.

Chloridizing Stamp Mills—dry to 16 mesh, 2—2.5.

Chloridizing Stamp Mills—wet to 40 mesh, 4—4.5.

Magnetic Separator Mills—0.25—0.5.

Cyanide Mills—Dry roll crushing to 20—30 mesh, 0.5—0.8.

Cyanide Mills—Wet stamp crushing and sliming to 80 mesh, 0.75—1.5

Cost of Power per H. P. per Day

Steam Power, non-condensing engines, coal at $4.50=16—18 cents.

Steam Power, condensing engines, coal at $4.50=14—16 cents.

Steam Power, compound-condensing engines, coal at $4.50=11—14 cents.

Note—For each $1.00 increased cost of coal above $4.50 per ton, add to the above figures 1½ cents per H. P. per day for non-condensing, 1¼ cents for condensing, and 1 cent for compound-condensing engines.

Electric Power, $40.00—$65.00 per H. P. per annum=11—18 cents.

An empirical figure for cost of steam power in mining camps in general is: 25 cents per H. P. per day.

POWER USED IN BOSTON MONTANA CONCENTRATOR

Machine	R. P. M.	H. P. Required
Hancock Jig	62	3.41
Evans Jig	190	0.50
Trommel (3x6 ft.)	...	0.30
Overstrom Table	251	0.364
Wilfley Table	251	0.352
Vanner (4 ft.)	182	0.230

Power Used in Concentrating Mills

Figures for mills No. 2 and No. 1 of the Cananea Consolidated Copper Company, Cananea, Mexico.

No. 2 MILL

		Horsepower
20	Trommels 4x5 ft. and 4x8 ft.	20
4	16-in. Elevators, 46 ft. between pulley centers.	10
4	Sets 16x36 in. Rolls at 80 R.P.M.	20
6	One-Compartment Bull Jigs (4 in use)	8
16	Two-Compartment Middle Jigs	16
16	Three-Compartment Sand Jigs	16
2	Dewatering Trommels	1
2	Chip Trommels	1
10	Shovelwheels with Shafting	3
2	Centrifugal Pumps, 1200 gal. per min., 40 ft. lift	60
8	5-ft. Bryan Mills	144
38	Wilfley Tables with Line Shafting	25
36	6-ft. Frue Vanners with Line Shafting	8
2	Centrifugal Pumps	25
6	Shaking Launders	3
2	Middling Elevators	5
2	Pulp Elevators	3
	Friction of Engine and Remaining Shafting	80
	Total on Mill Engine	472

1400 tons of ore treated per day.
0.337 H. P. per ton of ore.

No. 1 MILL

		Horsepower	
24	Trommels	12	
2	No. 1 Elevators	13	
2	No. 2 Elevators	14	
2	No. 3 Elevators	8	
2	No. 4 Elevators	8	
8	Bull Jigs (4 active)	8	
16	Two-Compartment Jigs	16	
8	Three-Compartment Jigs	8	
2	Bryan Mills	36	
2	No 1 Centrifugal Pumps	40	
2	Shaking Launders and 2 Shovelwheels	2	
2	16x36 in. Davis Rolls	22	
4	14x27 in. Davis Rolls	40	
	Shafting and Belts	40	
	Engine and Jackshaft Friction	50	
	Total Engine Load		317
42	Wilfley Tables	26	
36	Six-Foot Frue Vanners	8	
2	10x48 in. Sand Pumps	3	
1	No. 2 Centrifugal Pump	15	
	Friction of Transmission	13	
	Total Motor Driven Load		65
	Total Power Required in the Mill		382

1400 tons of ore treated per day.
0.273 H. P. required per ton of ore.

The power required to operate a concentrating mill should be calculated from the units which go to make up the mill. It is sometimes necessary to roughly estimate the power required in advance of the operation of the mill plans. In this case figure that a mill of from 50 to 100 tons capacity daily will require 1½ H. P. to treat each ton; from 100 to 200 tons capacity, about one H. P. per ton.

Richards Ore Dressing.

POWER REQUIRED FOR DIFFERENT PARTS OF GOLD MILLS

Each 7 x 9 Blake Rock Crusher	4 to 6 H. P.
Each 8 x 12 Blake Rock Crusher	5 to 7 H. P.
Each 9 x 15 Blake Rock Crusher	8 to 10 H. P.
Each 6 x 6 Dodge Rock Crusher	3 to 5 H. P.
Each 7 x 8 Dodge Rock Crusher	5 to 7 H. P.
Each 8 x 12 Dodge Rock Crusher	7 to 10 H. P.
Each 850-lb. stamp dropping 6", 100 times per min.	1.58 H. P.
Each 1000-lb. stamp dropping 6", 100 times per min.	1.90 H. P.
Each 4-foot Bryan Mill	5 to 6 H. P.
Each 5-foot Bryan Mill	10 to 12 H. P.
Each 6-foot Johnston Concentrator	about ½ H. P.
Each 20" Amalgam Barrel	1 to 2 H. P.
Each 24" Amalgam Barrel	2 to 3 H. P.
Each 18" Clean-up Pan	½ to ¾ H. P.
Each 24" Clean-up Pan	¾ to 1 H. P.
Each 36" Clean-up Pan	1 to 1¼ H. P.
Each 48" Clean-up Pan	2 to 3 H. P.
Each Ore Sampler and Grinder	2 to 3 H. P.
Each Belt-Driven Challenge Ore Feeder	¼ to ½ H. P.

Union Iron Works Catalog.

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CRUSHING WITH BLAKE TYPE OF BREAKERS

Abbreviations.—C. = solid cast-iron frame; Cap. = capacity; Est. = estimated; griz. = grizzly; HP. = horsepower; h = hours; In. = inches; L = lever pattern; Min. = minute; P = Pitman pattern; p = per; picked = poor residue left after picking; Rev. = revolutions; S. = sectional bolted frame.

Breaker No.	Pattern	No. used	Mouth size, inches	Rev. per min.	Feed size	Crushed to, inches	Actual Cap. per 24 hrs. per breaker tons	Est. cap. per 24 hr., tons	Run	Repairs per year exclusive of wearing parts	Est. HP.
1	....	1	6 x 8	450	Mine ore	....	50	125	Dry	......	..
1	P. C.	1	10 x 13	360	Mine ore	¾	100–120	300	Wet	$100	..
1	L. C.	1	6 x 8	500	Mine ore over 1½ in. griz.........	1	....	....	....	......	..
1	P. C.	1	10 x 16	250	Mine ore over 2 in. griz..........	2	50	150	Dry	(c)	20
1	P. C.	1	6 x 10	350	Mine ore	1	80	200	Wet	......	..
1	L. C.	1	6 x 9	125	Mine ore	¾	37½–40	112–120	Wet	None	4
1	L. C.	1	6 x 9	400	Mine ore picked	⅝	....	....	....	......	..
1	P. C.	1	7 x 10	320	Mine ore	1½	95	....	....	......	..
1	P. C.	1	9 x 11	...	Mine ore picked	1½	....	....	....	......	..
1	P. S.	1	8 x 10	300	Mine ore over 1¼ in. griz.........	1½	100	200	Dry	......	..
1	P. C.	1	7 x 10	250	Mine ore	1	40–50	....	Wet	......	..
1	P. C.	1	9 x 15	...	Mine ore	1½	100	....	....	......	..
1	L. C.	1	9 x 15	214	Mine ore	½	109	140	Wet	$155	..
1	L. C.	10	9 x 15	180	Mine ore	1½	90	125	Dry	$ 90	7
1	P. C.	2	9 x 15	250	Mine ore picked	1½	80	150	Wet	$ 20	..
2	P. C.	1	7 x 12	250	Mine ore over 1¼ in. griz.........	1½	100	....	Dry	......	7
1	P. C.	2	8 x 10	400	Mine ore	1 1/16	350	....	....	......	..
(a)	P. C.	1	9 x 15	340	Selected shipping ore	2½	....	....	Dry	......	10
(b)	P. C.	1	9 x 15	340	Mine ore picked, over 1¼ in. griz.	2½	....	....	Dry	......	25
1	P. C.	1	7 x 10	350	Mine ore picked	1½	200	230	Wet	......	7
1	P. C.	2	9 x 15	280	Mine ore over 1½ in. griz.........	1½	250	350	Dry	None	12
1	P. C.	1	7 x 11	224	Mine ore	....	75	....	Wet	......	..
1	P. C.	1	7 x 12	...	Mine ore over 1½ in. griz.........	....	60	....	Dry	......	..
1	P. C.	1	9 x 15	...	Mine ore	....	....	....	....	......	..
1	P. C.	2	10 x 20	300	Mine ore over 1 in. griz..........	1½	300	....	....	......	..
2	P. C.	4	7 x 10	300	(k) On No. 1 trommel 1½ in......	....	....	....	....	......	..
1	P. C.	2	9 x 15	350	Mine ore	2½	250	....	Wet	......	..
2	P. C.	2	4 x 10	250	(k) On No. 1 trommel 2⅛ in......	1	....	....	Wet	......	..
1	P. C.	2	9 x 15	275	Mine ore	2	300	400	Wet	None	..
2	P. C.	4	7 x 10	275	(k) On No. 1 trommel, 20 mm....	1	30	100	Wet	None	..
1	P. C.	1	9 x 15	250	Mine ore	2	300	400	Dry	Small	..
2	P. C.	1	7 x 10	250	(k) On No. 1 trommel, ⅞ in........	1	....	100	Dry	Small	..
1	P. C.	11	24 x 36	190	Mine ore over 3½ in. griz.........	12	480	....	Dry	......	..
2	P. S.	11	17 x 24	200	(k) On No. 2 grizzly 3½ in........	3½	....	....	Dry	......	..
1	P. C.	2	14 x 22	84	Mine ore over 4 in. griz..........	4	....	....	Dry	......	..
2	P. C.	2	13 x 20	140	Mine ore over 4 in. griz..........	4	....	....	Dry	......	..
1	P. C.	3	18 x 24	84	Mass copper rock (m)............	5	....	....	Dry	(e)	..
2	L. C.	6	9 x 15	129	From No. 1 breaker..............	2¾	....	....	Dry	......	..
3	P. C.	6	13 x 20	103	Copper rock (m)................	3	....	....	Dry	......	..
1	P. C.	4	18 x 24	132	Mine ore over 4 in. griz..........	4	....	....	Dry	......	..
1	L.	6	8 x 15	216	Mine ore over 4 in. griz..........	4	....	....	Dry	......	..
1	P. C.	1	10 x 15	250	Mine ore	1½	50	130	Dry	(p)	7
1	P. C.	3	9 x 15	200	Mine ore over 2 in. griz..........	1½	15	75	Wet	(f)	14
1	L. C.	2	9 x 14	200	Mine ore over 3 in. griz..........	3	20	....	Dry	......	..
1	P. S.	3	8 x 12	240	Mine ore over 1½ in. griz.........	1½	24	50	Dry	(g)	15
1	P. C.	1	9 x 12	250	Mine ore over griz..............	1½	15	....	Dry	......	..
1	P. C.	1	9 x 12	300	Mine ore over 1⅝ in. griz.........	1	116	200	Dry	$30	7
1	P. S.	1	10 x 16	200	Mine ore over 2 in. griz..........	2	110	....	Dry	......	..
1	P. C.	3	9 x 15	250	Mine ore over 1½ in. griz.........	1½	43	....	Dry	(r)	10
1	....	1	9 x 16	...	Mine ore over 2 in. griz..........	1½	100	....	Dry	......	..
1	P. S.	2	12 x 16	195	Mine ore over 2 in. griz..........	1½	75	....	Dry	......	..
1	P. S.	2	12 x 16	195	Mine ore over 2 in. griz..........	1½	75	....	Dry	......	..
1	P. C.	2	9 x 15	250	Mine ore over 1½ in. griz.........	1½	43	....	Dry	(r)	10
2	P. C.	2	9 x 15	200	(n) On trommel, 1 in............	1½	Under 50	100	Wet	(h)	12
1	P. C.	1	7 x 9	220	Mine ore	1½	....	....	Wet	......	..
1	P. C.	1	7 x 10	220	Mine ore	1	75	....	....	......	..
(d)	P. C.	1	8 x 12	252	Mine ore	1½	....	....	Dry	......	..
1	P. C.	1	9 x 15	250	Mine ore	1½	125	....	Dry	......	..
1	P. C.	1	7 x 12	...	....	1½	75	....	Wet	......	..
1	P. C.	1	12 x 24	270	Mine ore	2	125	300	Dry	None	15
2	P. C.	1	12 x 24	270	Product of No. 1 breaker.........	1	125	300	Dry	......	..
3	P. C.	2	9 x 17	270	Product of No. 2 breaker.........	¾	62	150	Dry	......	..
1	P. C.	1	9 x 15	200	Mine ore	1½	....	....	Dry	......	..
1	P. C.	1	15 x 30	270	Mine ore over 1½ in. griz.........	4	....	....	Dry	......	..
2	P. C.	1	(q)	276	(j)	¾	....	....	Dry	......	..
1	....	1	9 x 15	...	Mine ore	1½	80	200	Wet	......	..

(a) For shipping ore. (b) For concentrating ore. (c) Rubber springs, cost $3.50 each, last 2-4 weeks. (d) Sampler. (e) Twelve days a year. (f) Less than $20 per breaker per year. (g) Very hard ore, so that pitman sometimes breaks. (h) Babbitt for bearings. Jaw springs. (j) Product of No. 1 breaker, picked; also stuff through 1½-in. griz., picked. (k) Through No. 1 breaker. (m) Over 2¾-in. griz. and from fall hammer. (n) Through Comet breaker, 3 in. (p) Babbitt once in 2 years, nothing else. (q) This is a Duplex breaker with each mouth 6 x 20 in. (r) Babbitt bearings annually, cost $10.

Liddell's Chemists' and Metallurgists' Hand Book.

DIMENSIONS AND WEIGHTS OF STAMP BATTERY PARTS

WEIGHT OF STAMP—LBS.	850	900	950	1000	1050	1150	1250
Diameter of die..............................Ins.	8¾	8¾	9¼	9¼	9¼	9¼	9¼
Weight of forged steel die, 6 ins. high.................Lbs.	106	106	112	112	112	112	112
Weight of forged steel die, 7 ins. high.................Lbs.	121	121	140	140	140	140	140
Dimensions of Shoe; dia. by height of body............Ins.	8½x8	8½x8	9x8	9x8	9x8	9x9	9x9
Weight of forged steel shoe..........................Lbs.	150	150	170	170	170	185	185
Dimensions of head; dia. by height...................Ins.	8½x18	8½x19¼	9x17¾	9x17¾	9x19	9x20	9 x22
Weight of cast steel head...........................Lbs.	232	247	252	252	270	286	350
Dimensions of stem; dia. by length...................Ins.	3x168	3⅛x168	3¼x168	3⅜x168	3½x168	3⅝x168	3¾x168
Weight of mild steel stem...........................Lbs.	337	365	395	426	455	493	530
Dimensions of 3-keyed tappet; dia. by height..........Ins.	9x12	9x12	9x12	9⅛x14	9⅛x14	9¼x16	9¼x16
Weight of 3-keyed tappet, cast steel..................Lbs.	136	136	136	155	155	180	180
Dimensions of cam; dia. by width of face..............Ins.	*x2½	*x2½	*x2½	*x2½	*x2½	*x2½	*x2½
Dimensions of cam, dia. hub by length of hub..........Ins.	11x5¼	11x5¼	11x5¼	12x5¼	12x5¼	13x5½	13x5½
Dia. of 10-stamp cam shaft, 14 ft., 6 in. long............Ins.	5⅜	5⅜	5½	5¾	6	6½	6⅞
Wt. of 10-stamp cam shaft, 14 ft., 6 in. long............Lbs.	1120	1120	1170	1280	1395	1635	1800
Dimensions of cam shaft pulley, dia. by face..........Ins.	72x12	72x14	78x14	78x16	84x16	84x18	84x18

Denver Engineering Works Co.

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GENERAL TABLE OF ROLL DATA

Abbreviations.—Bl. = Blake breaker; cap. = capacity; est. = estimated; G. = Gates breaker; gr. = grizzly; h = hours; in. = inches; j.m. = jig middlings; L. = Lowry breaker; mag. = magnetic; max. = maximum; mid. = middlings; ov. = oversize; s. = sectional; th. = through; No. = number; tr. = trommel.

Roll No.	Feed	Product to	Space between rolls, in.	Diameter, in.	Face width, in.	Revolutions per minute	Est. horse-power required	Cap. per 24 h. tons (a) Actual	Cap. per 24 h. tons (a) Max.	Class (r)
1	From Bl.	Hand jig	¾	12	14	100	..	50	130	I
1	Th. Bl., ¾ in., on No. 1 tr., ½ in.	No. 1 tr., ½ in.	Close	22	14	22	..	300	...	II
2	J.m., th. ½ in.	No. 1 tr., ½ in.	Close	18	14	22	..	...	...	IV
1	Th. Bl., 1 in., on No. 1 tr., 2 mesh	No. 1 tr., 2 mesh	Close	26	12	20	..	...	...	II
1	Th. Bl., 1 in.	No. 1 tr., 0.487 in.	¾	22	14	42	..	40	...	I
2	J.m., 1 to 0.09 in.	No. 1 tr., 0.487 in.	Close	22	14	...	..	...	...	IV
1	(b)	No. 1 tr., 20, 10, 2 mm. (S.)	Close	18	14	75	..	60	70	I, IV
1	(c)	No. 1 tr., 15 mm.	Close	20	14	90	..	45	50	II, IV
1	Th. Bl., 1½ in., on No. 1 tr., 0.141 in.	No. 2 tr., 0.083 in.	¼	36	14	(d)	..	100	250	II
1	Th. Bl.	No. 1 tr., 3 mesh	...	...	..	...	..	...	...	I
2	Ov. No. 1 tr., 3 mesh	No. 2 tr., 5 mesh	...	...	..	...	..	...	...	III
1	(e)	No. 2 tr., 0.252 in.	½	24	12	92 (f)	..	100	...	II
2	Ov. of No. 2 tr., 0.252 in.	No. 2 tr., 0.252 in.	¼	24	12	100	..	60–80	...	II
3	J.m., 0.252 to 0.060 in.	No. 6 tr., 0.060 in.	Close	16	9	120	..	...	...	IV
1	Th. Bl., 1 in.	No. 1 tr., 0.177 in.	¼	27	14	80	10	(g)	...	
2	Ov. No. 1 tr., 0.177 in.	No. 1 tr., 0.177 in.	Close	24	14	80	10	25	...	III
1	Th. Krom breaker, 1 in.	No. 1 tr., 12 mm.	0.4	30	16	28 (h)	20	...	...	I
2	(i)	No. 1 tr., 12 mm.	Close	30	16	40	20	...	...	III, IV
1	Th. Blake, 1½ in.	No. 1 tr., 7 mm.	...	27	14	...	..	100	...	I
2	(j)	No. 1 tr., 7 mm.	Close	27	14	...	..	100	...	III, IV
1	Th. Bl., ½ in., on No. 1 tr., 10 mm.	No. 2 tr., 7 mm.	⅓ to ½	28½	12	24	..	75	100	II
2	Ov. No. 2 tr., 7 mm.; j.m., 10 to 0 mm.	No. 2 tr., 7 mm.	¼ to 3/16	30	12	24	..	142	190	III, IV
1	Th. Bl., 1½ in.; Ov. No. 1 tr., 6 mm.	No. 1 tr., 6 mm.	Close	30	14	8½	8	105	125	I
2	Jig skimmings, 6 mm. to 0	Jigs	Close	30	14	60	5	50	55	IV
1, 2	From Dodge breaker, 1 in.	No. 2 tr., 0.224 in.	⅛ to 3/16	36	16	42	9 (k)	100	150	I
3	Ov. No. 2 tr., 0.224 in.	No. 2 tr., 0.224 in.	Close	36	16	50	..	200	...	III
1	Th. Bl., 1½ in., on No. 1 tr., 1½ in.	No. 2 tr., ⅝ in.	½	36	14	42	..	150	...	II
2	Jig tailings, ½ to 21/64 in.	No. 9 tr., 21/64 in.	⅛	36	14	100	..	...	...	IV
1	(l)	No. 2 tr., 16 mm.	⅛	26	14	40	9	96	100	II, IV
2	J.m., 16 to 5 mm.; ov. No. 8 tr., 3½ mm.	No. 8 tr., 3½ mm.	Close	30	16	35	5	24	100	IV
1	Th. Bl., 17 mm.	No. 1 tr., 8 mm.	½	21	12	45	..	...	...	I
2	Ov. No. 1 tr., 8 mm.	No. 1 tr., 8 mm.	¼	21	16	40	..	...	...	III
3	Th. No. 1 tr., 8 mm., on No. 2 tr., 6 mm.	No. 2 tr., 6 mm.	Close	21	16	...	..	...	...	II
1	Th. gr., 1¼ in.; th. G. or Bl., 2½ in.	No. 1 tr., 25, 15, 10 mm. (S.)	½	36	14	40	10	275	...	I
2	Th. No. 1 rolls on No 1 tr., 25 mm.	No. 1 tr., 25, 15, 10 mm. (S.)	½	24	14	26	6	65	...	III
3	J.m., 25 to 7 mm.	No. 1 tr., 25, 15, 10 mm. (S.)	Close	30	16	30	10	250	...	IV
4	J.m., 7 to 0 mm.; ov. No. 3 tr., 5mm.	No. 3 tr., 5, 2½ mm. (S.)	Close	24	14	35	4	30	...	IV
1	Th. Bl., 1½ in.	No. 1 tr., 18, 15, 9 mm. (S.)	½	36	18	40	10	200	...	I
2	J.m., 1½ in. to 4 mm.	No. 1 tr., 18, 15, 9 mm. (S.)	¼	24	12	36	7	...	...	IV
3	J.m., 4 mm. to 0; j.m., 2½ mm. to 0	No. 3 tr., 2½ mm.	Close	24	12	...	7	...	...	IV
1	Th. Bl., 1½ in.; th. gr., 1½ in.	No. 1 tr., 12, 8 mm. (S.)	⅛	31	16	28	8	600	700	I
2	J.m., 1½ in. to 8 mm.	No. 4 tr., 5, 2 mm. (S.)	Close	36	14	55	9	350	450	IV
3	J.m., 8 to 5 mm.	No. 4 tr., 5, 2 mm. (S.)	Close	30	14	60	4	150	300	IV
4	J.m., 5 to 2 mm.	No. 4 tr., 5, 2 mm. (S.)	Close	30	14	60	4	150	300	IV
1	Th. Bl., 1 in., on No. 1 tr., 0.5 in.	No. 1 tr., 0.5, 0.31 in. (S.)	...	30	16	24½	..	...	...	II
2	J.m., 0.5 in. to 0	No. 2 tr., 0.2, 0.13 in. (S.)	Close	20	10	42	..	...	...	IV
1	Th. gr., 1½ in., th. G., 1½ in.	No. 1 tr., 15 mm.	...	30	14	48	..	300	...	I
2	Ov. No. 1 tr., 15 mm.; j.m., 15 to 11 mm.	No. 1 tr., 15 mm.	...	30	14	...	..	...	...	III, IV
3	J.m., 11 to 3 mm.	No. 5 tr., 3 mm.	...	30	14	...	..	...	...	IV
1	Th. gr., 1 in.; th. G., 1 in.	No. 1 tr., 16 mm.	½	26	15	62	10	300	...	I
2	(m)	No. 5 tr., 2½ mm.	Close	26	15	...	15	...	...	IV
1	Th. Bl.	No. 1 tr., 0.5 in.	...	24	14	...	..	...	...	I
2	Ov. No. 1 tr., 0.5 in.; j.m., 0.5 to 0.31 in.	No. 1 tr., 0.5 in.	...	20	10	...	..	...	...	III, IV
3	J.m., 0.31 in. to 0	No. 3 tr., 0.2 in.	...	20	10	...	..	...	...	IV
1	Th. G., 1½ in.; Ov. No. 1 tr., 25 mm.	No. 1 tr., 25 mm.	¾	26	15	40	..	...	...	II
2	J.m., 25 to 20 mm.	No. 1 tr., 25 mm.	½	26	15	47	..	...	...	IV
3	J.m., 20 to 3 mm.	No. 1 tr., 25 mm.	¼	20	12	37	..	...	...	IV
4	J.m., 10 to 3 mm.; ov. No. 7 tr., 7 mm.	No. 7 tr., 7, 3 mm. (S.)	1/16	42	12	42	..	...	...	IV
1	J.m., 1½ to ⅞ in.	No. 2 tr., ⅞ in.	½	26	15	60	..	...	...	IV
2	J.m., ⅞ to ⅜ in.	No. 2 tr., ⅞ in.	¼	26	15	60	..	...	...	IV
3	(n)	No. 6 tr., 2½ mm.	Close	26	15	60	..	...	...	IV
1	(o)	No. 2 tr., 1½ in., 15 mm. (S.)	3/16	30	16	38	..	...	...	IV
2	Jig tailings, 15 to 8½ mm.	No. 2 tr., 1½ in., 15 mm. (S.)	Close	26	15	40	..	...	...	IV
1, 3	From No. 2 Bl., 1 in.	No. 1 tr., 20 mm.	⅛	30	16	31	..	50	75	I
2	J.m., 20 to 7 mm.	No. 1 tr., 20 mm.	1/16	30	16	31	..	75	75	IV
4	J.m., 7 to 3 mm.; j.m., 3 to 0 mm.	No. 5 tr., 3 mm.	Close	30	16	60	..	120	120	IV
1	Th. No. 2 breaker	No. 2 rolls	...	30	15	16	..	...	...	I
2	From No. 1 rolls	No. 1 tr., ⅝ in.	...	30	15	24	..	...	...	III
3	J.m., ⅝ to ⅜ in.	No. 2 tr., ⅜ in.	Close	30	15	...	..	...	...	IV
4	J.m., ⅜ to ⅛ in.; ov. No. 5 tr., ⅛ in.	No. 5 tr., ⅛ in.	Close	30	15	...	..	...	...	IV
5	J.m., th. ⅛ in.	No. 5 tr., ⅛ in.	Close	30	15	...	..	...	...	IV
1	J.m., ¼ in. to 0; ov. 5 tr., 0.1 in.	No. 5 tr., 0.1 in.	Close	22	16	50	10	...	125	IV
1	J.m., 1 in to 3 mm.; ov. No. 2 tr., 3 mm.	No. 2 tr., 3 mm.	Close	30	16	60	..	65	100	IV
1	Th. Bl., 1½ in., on No. 1 tr., 4 mesh	No. 1 tr., 4 mesh	...	20	16	...	..	...	...	II
1	Th. Bl., 1½ in.	No. 1 tr., 0.224 in.	½	27	14	22	..	75	...	I
2	Ov. No. 1 tr., 0.224 in.	No. 1 tr., 0.224 in.	Close	20	10	30	..	...	...	III
1	Th. Bl., 1½ in.	No. 1 tr., 3 and 4 mesh	¼	36	14	40	..	100	125	I
2	Ov. of No. 1 tr., 3 and 4 mesh	No. 1 tr., 3 and 4 mesh	Close	36	14	37½	..	60	100	III
1	Th. Bl., 1½ in.	No. 1 tr., 3 mesh	½	27	14	40	..	75	...	I
2	Ov. of No. 1 tr., 3 mesh	No. 1 tr., 3 mesh	Close	27	14	...	..	...	...	III
1	Th. L., ¾ in.; th. No. 1 tr., 1 in.	No. 2 tr., 1/12 in.	Close	30	18	90	..	...	...	I
2	Ov. No. 2 tr., 1 to 1/12 in.	No. 2 tr., 1/12 in.	Close	30	18	100	..	...	...	III
3	Mid. of Mag. separator, 1/12 in. to 0	No. 2 tr., 1/12 in.	Close	30	18	100	..	...	...	IV
1	From Buchanan fine breaker, 1 in.	No. 2 rolls	½ to ¾	24	14	100	..	60	...	I
2	From No. 1 rolls	No. 2 tr. (p)	Close	18	12	130	..	60	...	III
1	Th. Bl., ¾ in., on No. 2 tr., ¼ in.	No. 3 tr., 0.060 in.	Close	30	15	34	..	90	120	II
2	Th. No.2 tr., ¼ in., on No. 3 tr., 0.060 in.	No. 4 tr., 0.058 in.	Close	24	16	130	..	25	40	II
3	Th. No. 9 tr., ¼ in., on No. 4 tr., 0.058 in.	No. 4 tr., 0.058 in.	Close	24	16	130	..	25	40	II
1	Th. Bl., 1½ in.	Log washer	1¼	30	14	25	..	80	190	I.
2	(q)	No. 1 tr., 6 mm.	1¼	24	12	30	..	10	...	III

(a) Actual capacity is what the rolls actually do in 24 hours; maximum capacity is what it is estimated they would do if run at their maximum capacity. (b) Th. Bl., 20 mm.; No. 1 jig tailings, 20 to 10 mm.; No. 2 j.m., 10 to 2 mm. (c) Th. No. 1 tr., 15 in., on No. 2 tr., 10 mm.; j.m., 10 to 0 mm. (d) One roll makes 44 revolutions, the other 45. (e) Th. gr., 1⅛ in., and Bl., 1½ in., on No. 1 tr., 0.252 in. (f) 102 revolutions per minute caused excessive wear. (g) 40 tons for hard ore, 60 for soft. (h) At 35 revolutions the rolls became glazed. (i) Ov. No. 1 tr., 12 mm.; j.m., 12 to 3 mm.; poor sand from trunking machine; poor settling table heads. (j) Ov. No. 1 tr., 7mm.; jig tailings, 7 to 3 mm.; j.m., 3 to 0 mm. (k) This is the result of actual measurement. (l) Th. Dodge, 1¼ in., on No. 1 tr., 40 mm.; ov. No. 2 tr., 16 mm:; jig tailings, 40 to 60 mm. (m) j.m., 25 mm. to sand; ov. No. 5 tr., 2½ mm. (n) Jig middlings, ⅜ in. to 2½ mm.; ov. No. 6 tr., 2½ mm. (o) Jig tailings, 1½ in. to 15 mesh; ov. No. 2 tr., 1⅛ in. (p) This varies from ¼ in. down to 20 mesh. (q) Ov. No. 1 tr, 6 mm., which treats No. 1 roll stuff. (r) The roll classes referred to in the above table, I, II, II, IV are: I. Rolls which crush the product of a breaker; II. Rolls which crush the product of a breaker after it has gone through a trommel; III. Rolls which crush the product of a previous pair of rolls. This may or may not have been screened; IV. Rolls that are crushing jig middlings.

Liddell's Chemists' and Metallurgists' Hand Book.

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CRUSHING WITH GYRATORY CRUSHERS

Abbreviations.—Br. = breakers; c. = comet; cap. = capacity; est. = estimated; g. = Gates; griz. = grizzly; H. P. = horse power; in. = inches; L. = Lowry; max. = maximum; No. = number.

Breaker No.	Pattern	No. used	Size	R. P. M. of pulley	R. P. M. of head	Size of Feed	Size crushed to inches	Actual capacity per 24 hrs.; tons	Estimated maximum capacity per 24 hrs. (a)	Repairs besides wearing parts	Estimated H. P. required	Head raised by
1	C	1	D	320	160	Mine ore	2½	200	(b)960	(c)	(d)30	Worm gear.
1	GG	1	4	340	170	Mine ore over 1¼ in. griz..	2½	250	960	(e)	20–25	.....
1	GG	2	3	425	212	Mine ore over 1½ in. griz..	1½	110	...	..	.....	.....
1	GG	1	3	500	250	Mine ore over 1 in. griz....	1	200	480	(f)	20	.....
1	C	1	6	...	...	Mine ore over 1½ in. griz..	2	75	...	..	.....	.....
1	GG	1	3	...	...	Mine ore	2	17	...	..	12	Screw to 6 in.
1	GG	1	3	425	212	Mine ore over ½ in. griz...	1	125	380	(g)	.....	Screw to 6 in.
1	GG	3	6	...	...	Mine ore	1½	200	...	..	.....	Screw to 6 in.
1	C	2	D	...	...	Mine ore	1 to 1½	60	...	..	.....	Shims up to 6 in.
1	C	1	D	400	200	Mine ore over 1½ in. griz..	3	100	...	(h)	40	Worm gear.
1	L	1	..	...	...	(i)	¾	...	...	..	.....	.....

(a) These are estimates by the mill managers. (b) This can probably crush 1440 tons in 24 hours. (c) Repairs, oil and other incidentals, $200 per year. (d) This is the result of actual measurement. (e) None except occasional babbitting. (f) Babbitt eccentric every 6 months. (g) Bevel gear and pinion gear. (h) Babbitting bearings. (i) Through No. 3 breaker on No. 1 trommel, 1 in.

Liddell's Chemists' and Metallurgists' Hand Book.

WEIGHT OF TUBE-MILL PEBBLE LOADS

By W. A. CALDECOTT

(From the Journal of the Chem., Met. and Min. Soc. of South Africa.)

Weight of Load in Tons of Pebbles (at 105 Lb. per Cubic Foot).

Pebble load in 22-ft. tube mill.	Internal diameter of tube-mill lining. 54 in.	55 in.	56 in.	57 in.	58 in.	59 in.	60 in.	61 in.	62 in.	63 in.
12 in. above axis of mill.....	14.21	14.65	15.10	15.55	16.02	16.48	16.96	17.44	17.92	18.42
11 " "	13.81	14.25	14.69	15.14	15.59	16.05	16.51	16.98	17.46	17.94
10 " "	13.41	13.84	14.27	14.71	15.15	15.60	16.06	16.52	16.99	17.47
9 " "	13.01	13.43	13.85	14.28	14.71	15.16	15.60	16.06	16.52	16.98
8 " "	12.60	13.01	13.42	13.84	14.27	14.70	15.14	15.59	16.04	16.50
7 " "	12.18	12.58	12.99	13.40	13.82	14.24	14.67	15.11	15.56	16.01
6 " "	11.76	12.15	12.55	12.95	13.36	13.78	14.20	14.63	15.07	15.51
5 " "	11.33	11.72	12.11	12.50	12.90	13.31	13.73	14.15	14.58	15.01
4 " "	10.90	11.28	11.66	12.05	12.44	12.84	13.25	13.66	14.08	14.51
3 " "	10.47	10.79	11.21	11.59	11.98	12.37	12.77	13.17	13.59	14.00
2 " "	10.04	10.40	10.76	11.14	11.51	11.90	12.29	12.68	13.09	13.50
1 " "	9.60	9.96	10.31	10.68	11.05	11.42	11.80	12.19	12.59	12.99
Level with axis of mill (i.e., half full).	9.18	9.53	9.88	10.23	10.60	10.96	11.34	11.72	12.11	12.50
1 in. below axis of mill.....	8.77	9.10	9.45	9.79	10.14	10.51	10.88	11.25	11.63	12.01
2 " "	8.33	8.66	9.00	9.33	9.69	10.03	10.39	10.76	11.13	11.50
3 " "	7.90	8.27	8.55	8.88	9.22	9.56	9.91	10.27	10.63	11.00
4 " "	7.47	7.78	8.10	8.42	8.76	9.09	9.43	9.78	10.14	10.49
5 " "	7.04	7.34	7.65	7.97	8.30	8.62	8.95	9.29	9.64	9.99
6 " "	6.61	6.91	7.21	7.52	7.84	8.15	8.48	8.81	9.15	9.49
7 " "	6.19	6.48	6.77	7.07	7.38	7.69	8.01	8.33	8.66	8.99
8 " "	5.77	6.05	6.34	6.63	6.93	7.23	7.54	7.85	8.18	8.50
9 " "	5.36	5.63	5.91	6.19	6.49	6.77	7.08	7.38	7.70	8.02
10 " "	4.96	5.22	5.49	5.76	6.05	6.33	6.62	6.92	7.23	7.53
11 " "	4.56	4.81	5.07	5.33	5.61	5.88	6.17	6.46	6.76	7.06
12 " "	4.16	4.41	4.66	4.92	5.18	5.45	5.72	6.00	6.30	6.58

The above table is calculated as follows:

Assume R = internal radius of lined tube-mill in inches.

V = height in inches from top of pebble load to lining.

L = length of tube-mill in feet.

F = Weight in pounds of one cubic foot of pebbles.

Then the general formula for the pebble load in tons is:

$$0.0001\ L\ F\ [0.1091\ R^2 - 0.0463\ V\sqrt{V(2R-0.608V)}].$$

The pebble load in tons of a tube-mill 22 ft. long, and with pebbles at 105 lb. per cubic foot, is:

$$0.0252\ R^2 - 0.0107\ V\sqrt{V(2R-0.608\ V)}.$$

The above formulae are derived from Molesworth's formula for the area of a segment, namely:

$$\frac{4\ V}{3}\sqrt{(0.626\ V)^2+C^2},$$

when V is the height of the segment, and C is the semichord.

When the upper surface of the pebbles is below the axis of the tube-mill, find the weight of the pebble load whose upper surface would be the same distance above the axis, and deduct this weight from the weight of the pebble load required to entirely fill the tube-mill.

Mining and Scientific Press.

CRUSHING IN HIGH-SPEED CHILEAN MILLS*

Mill	Type	Rev. per Min.	Capac. 24 Hrs.	Screen Mesh	Feed	Ore	Size of Product +30	+50	+60	+100	+150	+200	—200
Portland.....	Akron 6-ft...	34	124	30	¼-in.....	Hard.....	....	..	....	....	..	6.0	....
Independence..	Akron 6-ft...	33	120	30	⅜-in.....	Hard.....	....	21	....	12.0	5	62.0	....
Goldfield.....	Trent 6-ft....	32	75	30	4-mesh.....	Medium.....	4.0	10	....	25.0	6	6.0	49.0
Mogul.....	Monadnock...	..	105	30	1½-in.....	Hard.....	14.5	..	17.8	12.6	..	15.7	39.4

*Private Notes of H. A. McGraw.

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LOW-SPEED CHILEAN MILL DATA*

Size of Mill	Type of Ore	Size of Feed	Discharge	Consistency of Overflow	Tons per 10 Hrs.
10-ft.	Schist and hard quartz	1-in. ring	7½-in. overflow, no screen	80% water	19.4
10-ft.	Same ore as above	1-in. ring	6-in. overflow, 30-mesh screen	80% water	13.3
10-ft.	Hard, no talcose matter	¾-in.	7½-in. overflow	....	16.6
10-ft.	Tough, Close-grained quartz	....	7-in. overflow	....	13.3
10-ft.	Chunderlee, Australia	1¼-in.	7-in. overflow	....	16.6
10-ft.	Chunderlee, Australia	1¼-in.	9-in. overflow	....	16.6
10-ft.	Hard quartz	....	6½-in. overflow	82-84%	20–21
7-ft.	Brecciated quartz and andesite	....	10-in. overflow	80% water	.....

Size of Mill	Screen Analysis (not cumulative) +30	+40	+60	+80	+100	+120	—120	Rev. Per Min.	Remarks
10-ft.	0.428	0.858	2.376	5.346	13.848	3.656	73.482	....	....
10-ft.	none	none	0.87	3.959	13.017	5.952	76.049	8	Shows screen is a detriment
10-ft.	0.16	1.05	6.33	4.06	15.33	.....	......	8	6.84% on 150; 12.25% on 200; 53.42% through 200
10-ft.	.....	2.7	12.0	12.0	11.8	61.5		8	....
10-ft.	.....	1.0	2.0	3.0	4.0	90.0		....	To compare effect of height of discharge
10-ft.	.....	0.5	2.25	1.5	3.5	92.75		....	(To compare effect of height of discharge)
10-ft.	.....	3.0	12.0	11.0	13.0	61.0		8	Barnes-King Development Co., Mont.
7-ft.	.....	.....	......	3.4	12.5	....		7	Argonaut Mine. Cal. 62% minus 200

One horsepower will crush 1—2¼ tons of ore in slow speed mill.
*Original Notes of A. McLaren.

TUBE MILL DATA*

Relation Between Per Cent. Ore and Solution, Fineness of Grinding and Horsepower

Screen Analysis of Sand Fed to Tube Mills, 12 Ft. Long, 5 Ft. Diameter

On 20	On 30	On 40	On 60	On 80	On 100	On 120	On 150	Through 150
6.0	20.0	24.0	23.0	11.0	8.0	4.0	2.0	2.0

Variable Pebble Volume, Fixed Ore and Solution

Pounds, pebbles	On 60	On 100	On 150	Through 150	Per cent., ore	Per cent., solution	Tons ore per 24 hr.	Indicated horsepower
3,000	42.5	27.5	8.0	22.0	63.72	36.28	172	18.80
6,000	46.5	23.5	8.0	22.0	70.17	29.83	172	20.37
9,000	42.0	26.0	8.0	24.0	74.29	25.71	172	22.5
12,000	32.0	32.0	12.0	24.0	60.00	40.00	172	32.16
15,000	29.0	30.0	14.0	27.0	65.38	34.62	172	39.13
16,800	18.0	36.0	12.0	34.0	66.67	33.33	172	42.88
18,000	3.5	29.0	16.0	51.5	66.67	33.33	172	47.16
19,000	4.0	28.0	13.0	55.0	66.67	33.33	172	51.45
20,000	9.0	32.0	15.0	44.0	71.88	28.12	172	56.28
21,000	6.0	30.0	13.5	50.5	71.88	28.12	172	60.10
22,000	6.0	29.0	15.0	50.0	71.88	28.12	172	65.39
23,000	6.0	30.0	14.0	50.0	70.37	29.63	172	77.18
24,000	3.0	27.0	16.0	54.0	70.96	29.04	172	68.61
24,500	4.0	26.0	13.0	57.0	68.18	31.82	172	69.68
25,000	3.0	26.0	14.0	57.0	66.67	33.33	172	75.04
26,000	5.0	28.0	15.0	52.0	70.00	30.00	172	68.60
27,000	8.0	33.0	14.0	45.0	68.00	32.00	172	64.85

Variable Ore and Solution, Fixed Pebble Volume

Pounds, pebbles	Feed, inches	Tons ore per 24 hr.	On 60	On 100	On 150	Through 150	Per cent., ore	Per cent., solution	Indicated horse-power
20,000	3	172	7.0	32.0	13.0	48.0	64.71	35.29	56.4
20,000	3	172	13.0	35.0	11.0	41.0	66.67	33.33	54.28
20,000	3½	190	12.5	36.0	10.0	41.5	71.05	28.95	51.6
20,000	3½	190	14.0	34.0	12.0	40.0	67.86	32.14	54.8
20,000	4	216	16.0	34.0	14.0	36.0	68.18	31.82	53.2
20,000	4	216	14.0	36.0	16.0	34.0	69.70	30.30	49.4
20,000	4½	231	26.0	38.0	11.0	30.0	66.67	33.33	47.5
20,000	4½	231	30.0	30.0	10.0	30.0	72.22	27.78	43.5

Variable Solution, Fixed Pebble Volume and Ore Feed

Pounds, pebble	Ore feed, inches	Tons ore, per 24 hr.	Tons solution per 24 hr.	On 60	On 100	On 150	Through 150	Per cent., ore	Per cent., solution	Indicated horse-power
20,000	3	172	68.0	12.5	36.0	10.0	41.5	71.43	28.57	45.0
20,000	3	172	75.0	13.0	34.0	12.0	41.0	69.56	30.44	48.9
20,000	3	172	90.0	8.0	30.0	13.0	49.0	65.67	34.33	55.8
20,000	3	172	92.0	8.0	32.0	14.0	46.0	65.20	34.80	57.4
20,000	3	172	98.0	9.0	33.0	12.0	46.0	63.78	36.22	58.0
20,000	3	172	111.0	8.0	33.0	13.0	46.0	60.70	39.30	56.9
20,000	3	172	113.0	7.0	31.0	13.0	50.0	60.44	39.56	55.0
20,000	3	172	136.0	8.0	34.0	12.0	46.0	55.71	44.29	55.8
20,000	3	172	196.0	7.0	32.0	14.0	47.0	47.10	52.90	59.0
20,000	3	172	207.0	5.5	30.5	13.0	51.0	45.40	54.60	62.3
20,000	3	172	268.0	8.0	32.0	12.0	48.0	38.90	61.10	62.3

*Hofman, "General Metallurgy."

SCHEDULE OF RELATIVE SIZES OF STONE AND SCREENS

Size of Cube, Inches	Size of Ring, Inches	Size of Revolving Screen Perforation Inches	Size of Cube, Inches	Size of Ring, Inches	Size of Revolving Screen Perforation Inches
¼	⅜	½	1¾	2½	3
½	¾	⅞	2	2¾	3½
¾	1	1¼	2½	3½	4½
1	1½	1¾	3	4	5
1¼	1¾	2¼	3½	5	6
1½	2	2½			

Hendrie and Bolthoff Mfg. Co.

GOOD CONDUCTORS

Most Sulphides
(Examples) Pyrite
Chalcopyrite
Chalcocite
Galena

Native Metals
(Examples) Copper
Gold

Some Oxides
(Examples) Magnetite
Hematite

Certain Arsenic and Antimony Compounds
(Examples) Pyrargyrite
Tetrahedrite

Biotite
Graphite

POOR CONDUCTORS

Most Silicious Minerals and Rocks
(Examples) Quartz { Quartzite, Sandstone }
Feldspars { Granite, "Porphyry", Andesite, etc. }
Epidote
Garnet
Calamine

Most Carbonates
(Examples) Calcite—Limestone
Siderite

Most Sulphates
(Examples) Barite (Heavy Spar)
Gypsum

Sulphide of Zinc (Sphalerite or Blende)

Huff Electrostatic Separator Co.

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GRINDING PAN DATA

Data	Perseverance	South Kalgurli	Boulder	Associated	Kalgurli	Assoc. Northern
Monthly tonnage, 30 days	19,000	9030	18,000	11,600	10,700	3700
Daily tonnage	633	301	600	386	356	123
Tons on 150 mesh (requires grinding)	209	131	225	181	189	56
Tons through 150 mesh (already ground)	424	170	375	205	147	77
On 150 in percentages	33	43.6	37.5	47	53.1	45.5
Through 150 in percentages	67	56.4	62.5	53	46.9	54.5
Tons requiring grinding through 150	209	131	225	181	189	56
After grinding in pans on 150	28.4	12.6	29.0	10	20.8	12.5
After grinding in pans through 150	71.6	87.4	71.0	90	79.2	87.5
Percentage of total tonnage ground through 150 by pans	4.6	31.0	8.5	37	32.3	33.0
Tons ground through 150 of total daily tonnage	29.1	93.3	51.0	142	115	40.5
Number of pans	17	7	22	20	14	8
Diameter of pans	8	5.8′ and 2.5′	5	5	5	5
Area of a pan in square feet	50.2	50.2 and 19.6	19.6	19.6	19.6	19.6
Circumference of pan in feet	25.1	25.1 and 15.7	15.7	15.7	15.7	15.7
Revolutions per minute	10–30 and 7–25	33 and 55	60	55	55	47
Circumferential speed per minute	753 and 627	828 and 863	942	863	863	737
Total die area of pans in square feet	537	183	279	254	177	101
Total shoe area of pans in square feet	272	105	279	254	177	101
Tons ground per pan per day through 150	1.7	13.3	2.3	7.1	8.2	5.0
Horsepower per pan	8.0	12 and 7	7	7	7	5.1
Cost per pan per day at 3c. per horsepower hour	$5.76	$7.68	$5.04	$5.04	$5.04	$3.66
Cost per ton to grind sands through 150	28c.	58c.	18c.	66c.	58c.	72c.
Cost per ton on total tonnage	15c.	18c.	17c.	26c.	20c.	24c.
Area of discharge hopper at top, square inches	275	425	425	425	425	425
Tons requiring grinding per pan per day	12.3	18.7	10.2	9	13.5	7

Mining and Scientific Press.

COMPARISON OF STANDARD SIEVE SCALES

Mesh	Tyler Ratio = $\sqrt{2}$ = 1.414			Institution of Min. & Metall.			Amer. Soc. Testing Materials			U.S.Bureau Stand.		
	Openings		Diam. Wire,	Openings		Diam. Wire,	Openings		Diam. Wire	Opening	Diam. Wire,	Mesh
	Inches	Mm.	Inches	Inches	Mm.	Inches	Inches	Mm.	Inches	Inches	Inches	
...	1.050	26.67	.149	.....	.....	.....	.....	.....	.....	.....	.....	...
...	.742	18.85	.135	.....	.....	.....	.....	.....	.....	.....	.....	...
...	.525	13.33	.105	.....	.....	.....	.....	.....	.....	.....	.....	...
...	.371	9.423	.092	.....	.....	.....	.....	.....	.....	.....	.....	...
3	.263	6.680	.070	.....	.....	.....	.....	.....	.....	.....	.....	3
4	.185	4.699	.065	.....	.....	.....	.....	.....	.....	.....	.....	4
5	.....	.....	.....	.100	2.54	.100	.....	.....	.....	.....	.....	5
6	.131	3.327	.036	.....	.....	.....	.....	.....	.....	.....	.....	6
8	.093	2.362	.032	.062	1.574	.063	.....	.....	.....	.....	.....	8
10	.065	1.651	.035	.050	1.270	.050	.079	2.00	.022	.....	.....	10
12	.....	.....	.....	.0416	1.056	.0417	.....	.....	.....	.....	.....	12
14	.046	1.168	.025	.....	.....	.....	.....	.....	.....	.....	.....	14
16	.....	.....	.....	.0312	.792	.0312	.....	.....	.....	.....	.....	16
20	.0328	.833	.0172	.025	.635	.025	.0335	.850	.0157	.0335	.0165	20
25	.....	.....	.....	.020	.508	.020	.....	.....	.....	.....	.....	25
28	.0232	.589	.0125	.....	.....	.....	.....	.....	.....	.....	.....	28
30	.....	.....	.....	.0166	.421	.0167	.0197	.500	.013	.0223	.0110	30
35	.0164	.417	.0122	.....	.....	.....	.....	.....	.....	.....	.....	35
40	.....	.....	.....	.0125	.317	.0125	.0142	.360	.0102	.....	.....	40
48	.0116	.295	.0092	.....	.....	.....	.....	.....	.....	.....	.....	48
50	.....	.....	.....	.010	.254	.010	.0114	.290	.0083	.....	.....	50
60	.....	.....	.....	.0083	.211	.0083	.....	.....	.....	.....	.....	60
65	.0082	.208	.0072	.....	.....	.....	.....	.....	.....	.....	.....	65
70	.....	.....	.....	.0071	.180	.0071	.....	.....	.....	.....	.....	70
80	.0069	.175	.0056	.0062	.157	.0063	.0067	.170	.0059	.....	.....	80
90	.....	.....	.....	.0055	.139	.0055	.....	.....	.....	.....	.....	90
100	.0058	.147	.0042	.005	.127	.005	.0055	.140	.0046	.0055	.0045	100
120	.....	.....	.....	.0042	.107	.0041	.....	.....	.....	.....	.....	120
150	.0041	.104	.0026	.0033	.084	.0033	.....	.....	.....	.....	.....	150
200	.0029	.074	.0021	.0025	.063	.0025	.0029	.074	.0021	.0029	.0021	200

SPECIMEN FORM SHEET FOR ELECTROSTATIC SEPARATION

(Information Desired by Manufacturers)

Ore No. .....

A knowledge of the following matters is essential to an understanding of your problem, and will enable us to advise you concerning the commercial application of the process to your particular proposition. Please fill in the blanks below, and if any of the subjects require more detailed explanation, kindly give it in your accompanying letter.

COMPANY (name and office)

MINE (name and location)

Distance from railroad and smelters.
Character and extent of deposit. Country rock.
Present milling equipment.
Available tonnage for mill. Proposed daily tonnage.
Availability of water supply. Fuel available and cost at mine.

THE PROBLEM

General analysis of material to be treated.
Desired results in concentration or separation.
Prior investigation of ore (past and present concentration difficulties)
Is zinc present in recoverable amounts?

HOW TO SHIP SAMPLES

Send small amounts, up to four pounds, by mail. Larger amounts by **prepaid** freight or express, in good canvas bags, tagged, directions and name of shipper in ink. Also place inside sack, written on paper and folded, or better on wooden tag, name and kind of ore and name of mine. This is to insure identification in case of loss of outside tag. Be careful that samples represent fairly the character of the material to be treated. Please send a letter at time of shipment stating number of samples sent, together with as much relevant data as possible.

Huff Electrostatic Separator Co.

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Allis-Chalmers Manufacturing Company

MILWAUKEE, WISCONSIN

For Branch Offices and Other Products, See Page 168

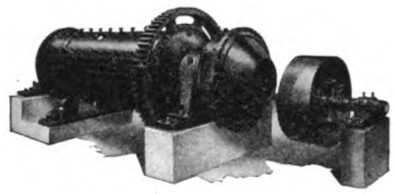
Ore Dressing and Milling Machinery

Products

Concentrating, Cyanide, Ore Washing and Sampling Plant Equipment. Stamp Mill Equipment; Classifiers; Blake and Dodge Jaw Crushers; Mill Elevators; Feeders; Bin Gates; Ball and Pebble Granulators; Sample Grinders; Grizzlies; Hartz and Hancock Jigs; Flotation Machines; Rod Mills; Crushing Rolls; Revolving Screens; Isbell and Frue Vanners; Log Washers, and Perforated Metal.

Rod Mills

The rod mill as designed by the Allis-Chalmers Manufacturing Company has proved its efficiency as a regrinding mill and can be furnished in sizes from 3′-0″ to 6′-0″ diameter, and for both wet and dry grinding. Bulletin 1821.

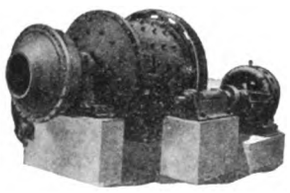


Rod Mill

Ball Granulators

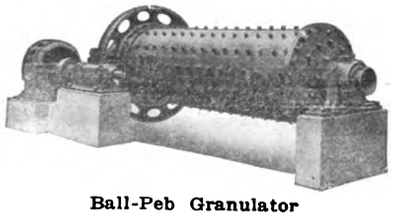
The ball granulator as developed by the Allis-Chalmers Manufacturing Company, represents the highest type of design, workmanship and material in its construction.

Built in standard sizes from 3′-0″ x 3′-0″ to 8′-0″ x 6′-0″ with direct motor or spur gear and pulley drive.



Ball Granulator

Shell liners of either white iron, chrome, or manganese steel of the latest and most approved type. Bulletin 1813-B.



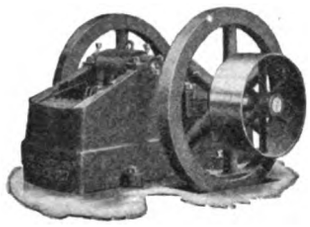
Ball-Peb Granulator

Ball-Peb Granulators

The Allis-Chalmers Manufacturing Company has designs and patterns to cover every practical size of Ball-peb granulator, ranging in diameter from three feet to eight feet and up to and including twenty two feet lengths, furnished with any standard type of drive ,geared, belted or direct connected to motor. Bulletin 1813-B.

Jaw Crushers

The Allis-Chalmers Manufacturing Company build both the Blake and Dodge type of jaw crusher. The Blake type can be furnished in sizes ranging from 10″ x 7″ to 60″ x 48″. The Dodge type jaw crusher can be furnished in sizes ranging from 4″ x 6″ to 11″ x 15″.



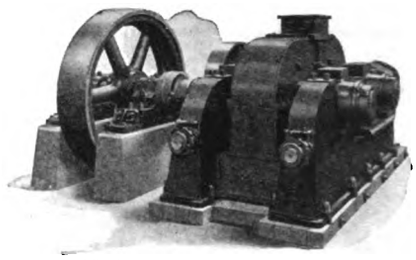
Type "B" Blake Crusher

Our well known type "B" Blake crusher as shown in illustration can be furnished in sizes from 10″ x 7″ to 30″ x 18″. The larger sizes are made with cast steel sectional frames, or semi-steel frames with re-inforcing rods.

We can furnish the 10″ x 7″ Blake and 7″ x 9″ Dodge type jaw crushers sectionalized for mule-back transportation. Bulletins 1451-B and 1810.

Crushing Rolls

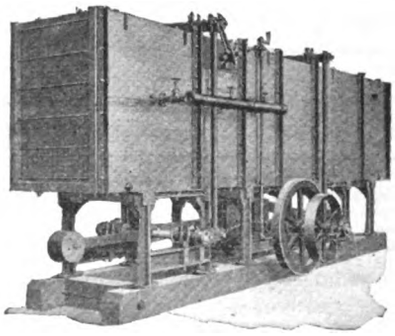
The Allis-Chalmers Manufacturing Company build a complete line of crushing rolls of various designs, ranging in size from 9″ to 72″ in diameter and from 9″ to 24″ width of face, having spring pressures up to fifteen tons per inch in width of face. We are in a position to furnish rolls suitable for the most exacting requirements. Bulletins 1812, 1815-A, 1816-A, 1817-A.



72″x24″ XX Crushing Rolls

Hancock Jigs

The Hancock Jig is of the movable sieve type. It has solved many difficult problems in the treatment of large tonnages of the low grade ores of copper, lead, zinc, manganese, chrome and sulphides of iron. The capacity ranges from one hundred to six hundred tons per twenty-four hours, depending on the mineral content of the ore. The feed does not require carefully graded sizing. Mixed feed as coarse as 5/8″ and as fine as 30 mesh is handled efficiently. The Hancock Jig requires 5 H.P. which is less than one-fifth of that required for Plunger jigs of equal capacity; requires less than 50% of the water used with Plunger jigs.



Hancock Jig

Bulletin 1820.

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CHALMERS & WILLIAMS, Inc.

1402 Arnold Street, CHICAGO HEIGHTS, ILL.

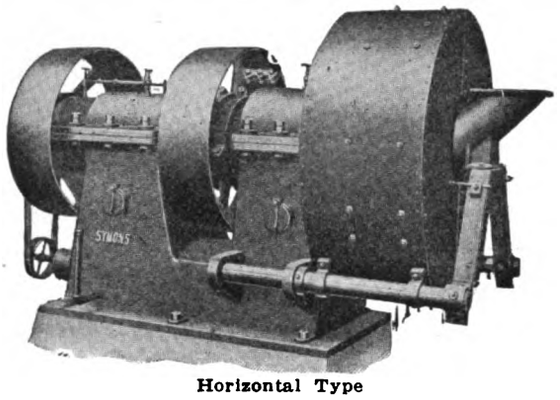
Crushing and Mining Machinery

Products

Symons Disc Crushers; Ross Grizzly; Ball, Pebble and Tube Mills; Burt Filters; Crushing Rolls; Stamp Mills; Jaw and Gyratory Crushers; Huntington and Chile Mills.

Symons Disc Crushers

An entirely new crushing movement, the crushing being done between two manganese steel discs at the same time being given a very rapid rocking



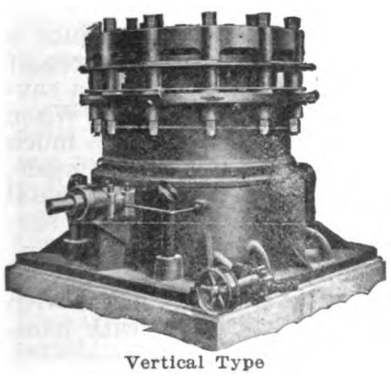
Horizontal Type

movement by means of an eccentric. The material is thrown out by the centrifugal force the instant it is crushed to the required size, so that the difficulty of "packing" met with in crushing to small sizes in jaw and gyratory crushers is overcome. The discs wear smooth and not in grooves permitting wear to be readily taken up.

These crushers are specially adapted for the crushing of hard rock, gravel, ore, etc., and produce a very uniform sized product.

TABLE OF WEIGHTS AND CAPACITIES FOR 18, 24, 36, 48-INCH SYMONS DISC CRUSHER

Size of Crusher	18-inch	24-inch	36-inch	48-inch
Approximate Shipping Weight	5600	8500	23,500	39,000
Size of Feed	1½-inch	2½-inch	3½-inch	6½-inch
Minimum Exit Opening for best results	⅜-inch	½-inch	¾-inch	1-inch
	Size of Ring / Tons Per Hour	Size of Ring / Tons Per Hour	Size of Ring / Tons Per Hour	Size of Ring / Tons Per Hour
Minimum Capacity in tons per hour	⅜ = 5- 8 ½ = 8-10 ¾ = 10-12 1 = 12-15	½ = 12-15 ¾ = 18-20 1 = 20-25 *1½ = 25-30	¾ = 25-30 1 = 30-45 1½ = 45-60 *2 = 50-65	1 = 45- 60 1½ = 60- 80 *2 = 80-100 *2½ = 100-120
R. P. M. Main Pulley	200	200	133	100
R. P. M. Eccentric Pulley	450	400	300	250
Size of Pulleys	28x 8	34x10	44x14	54x16
H. P. requirel	12–18	18–25	30-40	50–65



Vertical Type

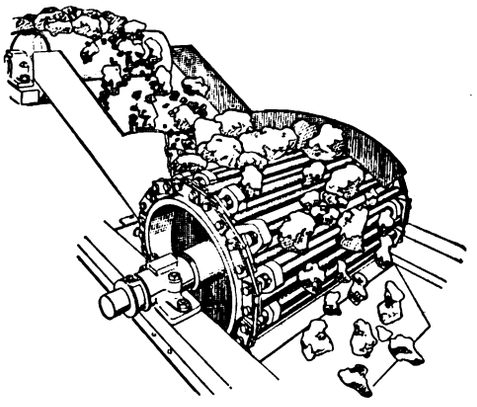
Vertical Type

Made in one size with several types of crushing discs to permit of fine, intermediate or coarse crushing.

Principal advantages are: large capacity per unit, low horse power, large range of reduction, uniform product.

Ross Automatic Drop Bar Grizzly Feeder and Screen

In operation, the screen surface moves past the feed lip, and at once thins out the material to a



Ross Automatic Drop Bar Grizzly Feeder and Screen

one-ply scattered load. Every piece of the feed has a clean contact and the separation of a small from a large piece is simple and practically instantaneous. The time to separate pieces of undersize from the oversize, above all others, is at the instant of contact. The material cannot be in a more perfect condition for separating than when falling or sliding freely to the screen. The great opportunity— it might be said the only opportunity of making a complete separation—is at this instant.

Observing the Ross Screen in operation, one is first struck with its easy running and effortless efficiency. Closer examination discloses the following distinguishing characteristics:

1. The rapid and easy flow of the undersize through the apertures immediately at the feed lip.

2. The single sharp knock and jump of each oversize piece when it hits the screen bar which leaves it perfectly free of fines or dust.

3. The sparseness of the scattered oversize pieces traveling to the discharge.

4. The complete absence of any undersize pieces on the screen surface beyond the immediate vicinity of the feed lip.

5. The extreme simplicity in the release of all pieces when at the discharge point no matter how tightly they have been knocked or squeezed in between the bars.

6. The absolute freedom from—and the impossibility of—blocking or choking.

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C. G. BUCHANAN CO., Inc.

90 West Street, NEW YORK, N. Y.

Crushing Machinery

Products and Service

Crushers and Crushing Rolls.

Bucket Elevators. Revolving Screens.

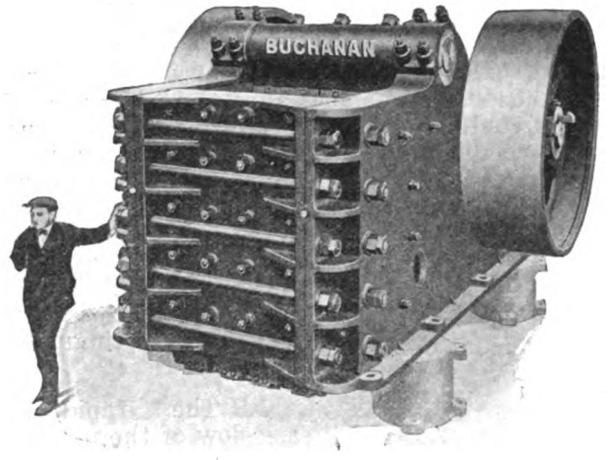
Magnetic Separators and Head Pulleys.

Designers and builders of Complete Stone Crushing and Concentrating Plants.

Buchanan All-Steel Crushers

Type "C"—This type Buchanan crusher is made in over 20 sizes to meet varying conditions. All bearings are water-jacketed and in the larger sizes are removable. Jaw, cheek plates and toggle bearings are manganese steel. Pitman is spring balanced and made parting with underfeed and overfeed lubrication provided for the bearings. All crushers fitted with our adjustable jaw stroke. Several sizes of Buchanan crushers are made sectional for convenience in handling for underground operations. All steel castings thoroughly annealed.

Adapted for preliminary crushing of rocks and ores to sizes suitable for feeding to secondary crushers. Fully described in Bulletin 10.



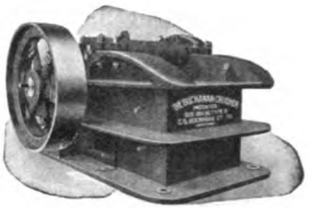
Buchanan Type "C" Crusher

STANDARD SIZES, WEIGHTS, CAPACITIES, SPEEDS, ETC., IMPROVED TYPE "C" CRUSHER

Type	Jaw opening, in.	Approximate weight, lbs.	Speed, r. p. m.	Tons per hour to sizes below (Approximately)						Size of pulley, in.	Approximate h.p. required
				tons	in	tons	in.	tons	in		
Box-Course	60x84	550,000	85	285 to 8		360 to 10		450 to 12		168x36	250-300
Box-Coarse	48x72	264,000	125	315 to 7		360 to	8	450 to 10		120x30	150-180
Box-Coarse	48x60	244,000	125	260 to 7		300 to	8	375 to 10		120x24	140-165
Box-Fine	42x72	262,000	125	225 to 5		270 to	6	315 to	7	120x36	150-180
Box-Fine	42x60	244,000	125	185 to 5		225 to	6	260 to	7	120x36	140-165
Box-Medium	42x54	195,000	150	250 to 7		290 to	8	360 to	10	90x36	125-150
Box-Fine	38x54	193,000	150	215 to 6		250 to	7	290 to	8	90x36	125-160
Panel-Coarse	42x48	173,500	150	225 to 7		260 to	8	320 to	10	90x30	110-140
Panel-Fine	38x48	171,500	150	160 to 5		190 to	6	225 to	7	90x30	110-140
Panel-Coarse	36x54	130,000	175	225 to 6		300 to	8	375 to	10	84x24	125-150
Panel-Fine	32x54	128,500	175	185 to 5		225 to	6	260 to	7	84x24	125-150
"Special" (Box)-Fine	36x48	172,000	175	130 to 4		165 to	5	200 to	6	84x24	125-150
Panel-Coarse	36x48	118,000	175	190 to 6		260 to	8	325 to	10	84x18	100-125
Panel-Fine	32x48	117,000	175	160 to 5		190 to	6	225 to	7	84x24	100-125
Panel-Coarse	36x42	116,000	175	175 to 6		235 to	8	290 to	10	84x18	90-115
Panel-Fine	32x42	115,500	175	145 to 5		175 to	7	200 to	7	84x18	90-115
Panel-Fine	30x48	115,500	175	145 to 4½		190 to	6	225 to	7	84x24	100-125
Panel-Fine	30x42	110,000	175	115 to 4		145 to	5	175 to	6	84x20	90 115
Panel-Coarse "Special"	30x42	70,000	200	175 to 6		200 to	7	235 to	8	70x24	90-115
Panel-Fine "Special"	24x42	69,000	200	85 to 3		115 to	4	145 to	5	70x24	90-115
Panel-Fine "Special"	24x48	110,000	200	100 to 3		135 to	4	200 to	6	70x24	110-135
Panel-Coarse	30x36	68,500	200	90 to 5		105 to	6	125 to	7	70x18	60- 75
Panel-Fine	24x36	67,000	210	45 to 3		60 to	4	75 to	5	70x18	60- 75
"Sectional"	24x36	68,000	210	45 to 3		60 to	4	75 to	5	70x18	60- 75

Type "B"—Constructed with main frame cast of steel in one solid piece. Made in 20 sizes from a 2x4 in. laboratory crusher to 24x36 in. for preliminary crushing. Jaw and cheek plates of manganese steel. Pitman water-jacketed, and in larger sizes (over 12 x20 in.) made parting. Equipped with our patent adjustable jaw stroke for increasing or decreasing stroke for fine or coarse crushing. Phosphor bronze removable bearings on all sizes up to and including 12x20 in. All steel castings thoroughly annealed.

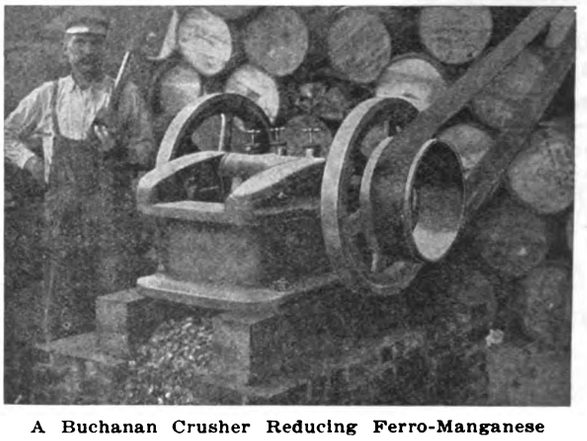
Detailed description in Bulletin 9.



Front View Buchanan 18x36 in. Type "B" Crusher

STANDARD SIZES, WEIGHTS, CAPACITIES, SPEEDS, ETC., TYPE "E" CRUSHER

Size receiving capacity, in.	Approximate capacity in tons, per day of 10 hours to any one of sizes stated								Size of pulley, in.	Speed, r.p.m.	H.P.	Approximate total weight, lbs.
	tons	in.	tons	in.	tons	in.	tons	in				
2x 4	.....		.....		.....		.....		.....	.....	Belt or hand	163
4x12	30 to	2½	20 to	1½	15 to	1	8 to	½	18x 8	300	4- 5	2,775
8x14	100 to	2½	85 to	2	60 to	1½	35 to	1	24x10 (1)	275-300	8-12	6,500
10x16	170 to	3	150 to	2½	125 to	2	100 to	1½	30x12 (1)	275-300	12-18	9,300
12x20	230 to	3	200 to	2½	175 to	2	130 to	1½	36x12 (1)	250-275	18-25	15,000
13x24	300 to	3	260 to	2½	215 to	2	160 to	1½	42x 8 (2)	250-275	20-30	24,600
15x24	400 to	4	350 to	3½	300 to	3	.....		42x 8 (2)	250-275	20-30	23,500
13x30	375 to	3	320 to	2½	275 to	2	200 to	1½	42x10 (2)	250-275	30-40	33,000
15x30	500 to	5	450 to	4	375 to	3	.....		42x10 (2)	250 275	30-40	33,450
16x36	650 to	4	575 to	3½	500 to	3	400 to	2	42x10 (2)	250-275	50-60	47,750
18x36	900 to	6	800 to	5	650 to	4	575 to	3½	48x14 (2)	250-275	50-60	57,000
24x36	1000 to	6	850 to	5	750 to	4½	700 to	4	48x14 (2)	250-275	50-60	57,000



A Buchanan Crusher Reducing Ferro-Manganese

The crusher can be adjusted to produce a very uniform product of any desired degree of fineness, from 1½ to ½ in. size, effecting a saving of from 20% to 25% of manganese. When manganese is crushed to a uniform size a much better and more intimate mixture can be made, thereby producing a much better quality of metal and at the same time effecting a very marked saving in the use of manganese.

A very important economy is the saving through the use of a crusher as compared with the old hand method of breaking up with hammers, with much waste.

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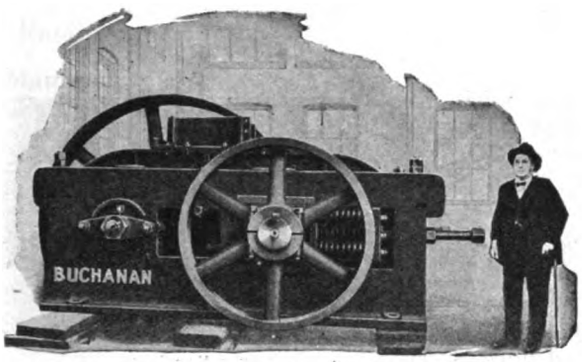
Crushing Rolls

These rolls are made in sizes from18x12 in. to 42 x16 in. and special from 36x18 in. to 72x36 in. Phosphor bronze bearings. Stationary roll provided with fleeting adjustment to provide moving roll sideways to prevent grooving. The adjustable or moving roll is provided with our patent swivel pillow blocks to keep bearings in alignment and prevent cramping of the shafts when passing iron or other hard substances through the rolls.

Bulletin 13 gives further details and describes our other crushing rolls.

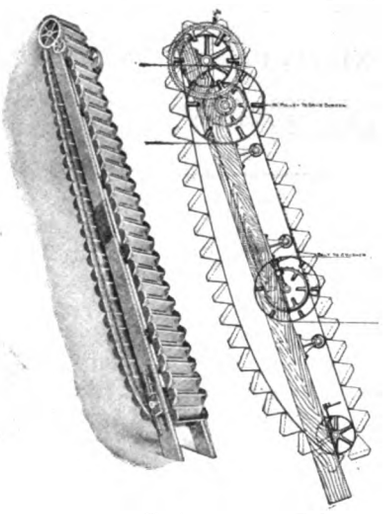


Buchanan Type "C" Crushing Rolls

Bucket Elevators

In crushing plants, elevators as a rule give more trouble and cause more loss of time than any other piece of equipment. The reason is that frequently the elevator or conveyor installed is not adapted for the work it is intended to perform. When properly designed and built, the elevator will cause no more trouble than any other equipment exposed to the abrasive action of the material handled.

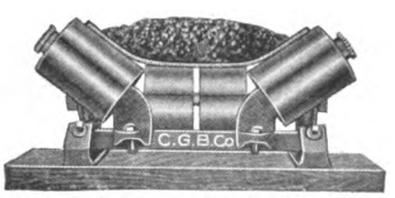
We build and have patterns for a full line of elevators, either chain or belt, using buckets from 4 to 6 in. up to and including 24x60 in., having capacities from 10 to 500 tons per hour.



Chain Belt
Bucket Elevators

Belt Conveyors

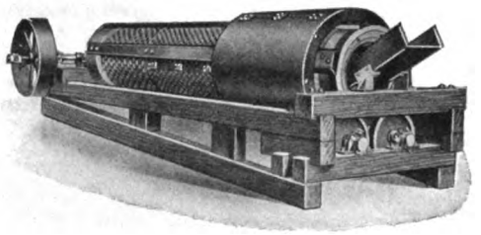
In connection with our crushing machinery, magnetic separators and magnetic head pulleys, we furnish belt conveyors of the most approved design, in all sizes, adapted for either fine or coarse material.



Belt Conveyor

Revolving Screens

These screens are well designed and built of the best material for the purpose. They are largely used for screening coarse or medium fine material. Screen sections are removable for replacement without the necessity of taking entire screen apart. When desired, dust jacket can be furnished for removal of dust.

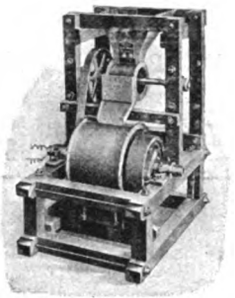


Buchanan Girder Type Revolving Screen
Made in a number of sizes, from 36 in. x 12 ft. up to and including 72 in. x 30 ft.

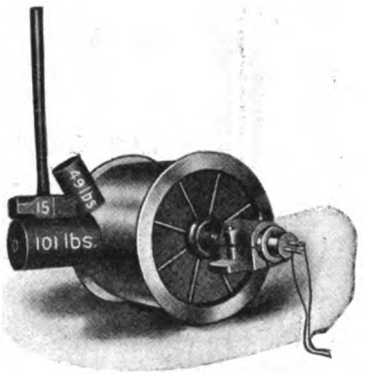
Magnetic Separators and Head Pulleys

These separators are designed for use in the treatment of iron or other magnetic ores, also for separating iron from brass turnings or similar purposes. Another use is separating "tramp iron" from materials being pulverized.

Drum Separator—The Buchanan standard. Has magnets with pole pieces of alternating polarity. Built in sizes from 14x6 in. to 36x24 in., with or without automatic feed.

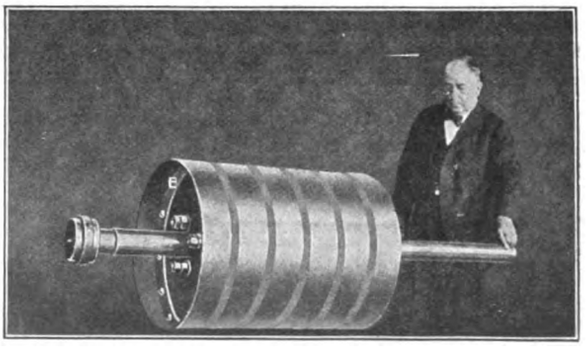


Buchanan Magnetic Drum Separator



Illustrating the Magnetic Influence of Buchanan Drum

Head Pulleys—Buchanan magnetic head pulleys are made in sizes from 12x12 in. to 42x36 in. or wider if desired. Very strong and simple in construction. Used on conveyor belts in place of the regular head pulley.



Buchanan Magnetic Head Pulley

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Gruendler Patent Crusher & Pulverizer Co.

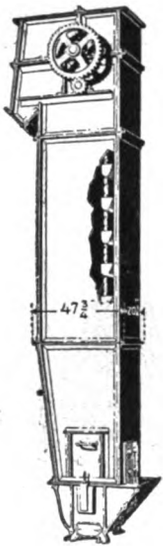
992 N. Main St., ST. LOUIS, MO.

Manufacturers of

GRUENDLER
CRUSHERS · PULVERIZERS · GRINDERS

Products

Jaw and Gyratory Crushers, Shredders, Pulverizers with air separation, Roller Mills with air separation, Revolving and Vibrating Screens, Conveyors, Elevators, Packing Machinery, Rotary Dryers, etc. We design, install and manufacture crushing, pulverizing and conveying machinery for the handling of all mineral and similar products, also complete machinery for grinding and mixing plants.



Gruendler Elevators

You can't afford to have shutdowns in your crushing and pulverizing departments. Every delay in these departments will mean thousands of dollars loss to you. Gruendler Crushers and Pulverizers, Screening, Elevating and Conveying Machinery have stood the test for 35 years, giving satisfactory service in hundreds of plants with fewer shutdowns than other machines and giving a uniform material at less cost per ton of finished material.

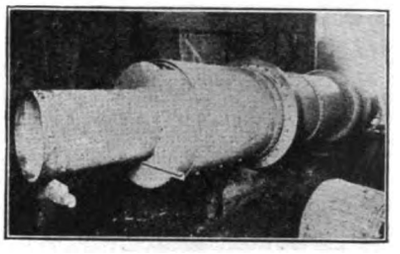
Service

Write us for further information. Our engineers are always at your service. Call on them.

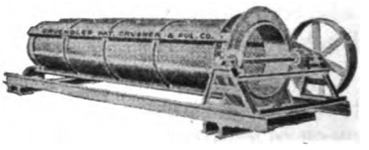
LET GRUENDLER BUILD YOUR NEXT PLANT

APPROXIMATE SPEED CAPACITY AND POWER LIST—GRUENDLER HERCULES SHALE AND CLAY CRUSHERS AND PULVERIZERS, WITH OR WITHOUT STEAM JACKET

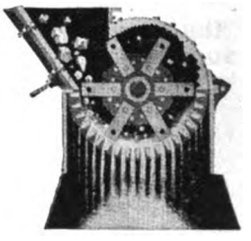
No.	Size	Approx. H. P.	Approx. Weight, Lbs.	Speed, R. P. M.	Size Pulley	Approx. Capacity per Hour, ⅛" Bar Opening, Tons
X	18"	7	1,200	1200 to 1500	8x 7"	1 to 1½
XB	18"	10	1,350	1200 to 1500	9x 8"	2 to 3
XXB	24"	15	2,700	1200	12x10"	4
XXC	24"	25	3,000	1200	14x12"	5
XXX	30"	30	4,500	1000 to 1200	16x12"	6 to 8
XXXD	30"	35	5,500	1000	16x12"	8 to 10
XXXX	36"	45	6,500	1000	16x14"	10 to 12
XXXXE	36"	65	7,500	1000	16x16"	15
XXXXF	42"	75	8,500	900	20x18"	20
XXXXG	42"	100	15,000	900	24x22"	30
XXXXH	42"	110	17,000	800	24x26"	40
XXXXI	42"	120	20,000	600 to 800	24x28"	60 to 70



Gruendler Rotary Dryer

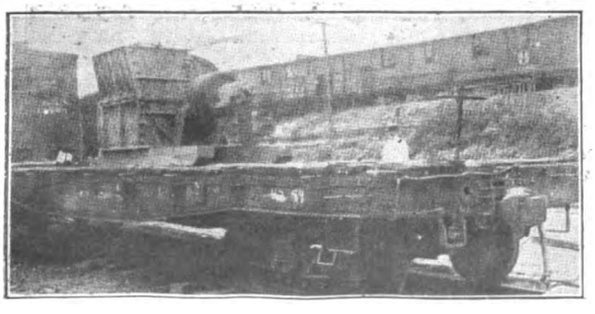


Gruendler Revolving Screens



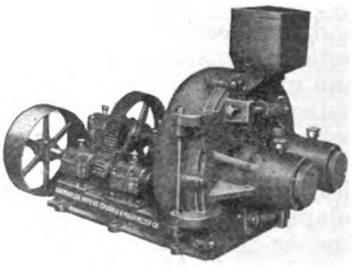
Interior View Swing Hammer Crusher

Gruendler Jaw Crusher



Monster Crusher on Flat Car

THE BEST THAT MONEY CAN BUY



Gruendler Roller Mill

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The Williams Patent Crusher & Pulverizer Co.

Plant and General Offices: 2703 North Broadway, ST. LOUIS, MO.

Chicago Offices and Showroom
37 W. Van Buren Street

San Francisco Offices and Showroom
67 Second Street

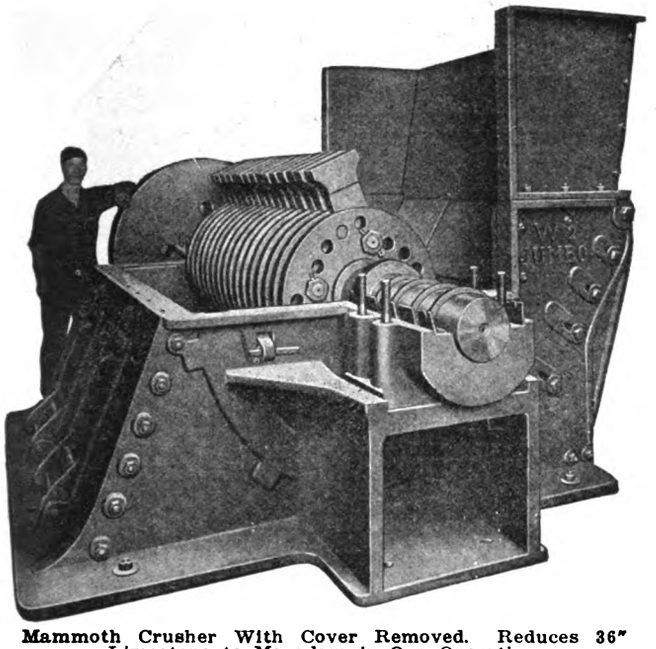
New York City
Philadelphia
Denver
Scranton
Los Angeles
Richmond
Rochester
Seattle
Chattanooga
Detroit
Salt Lake City

Products

Hinged Hammer Crushers and Pulverizers for Limestone, Lime, Asphalt Rock, Coal, Iron Ore, Talc, Kaolin, Shale, Clay, Marl, etc.

The Mammoth Crusher

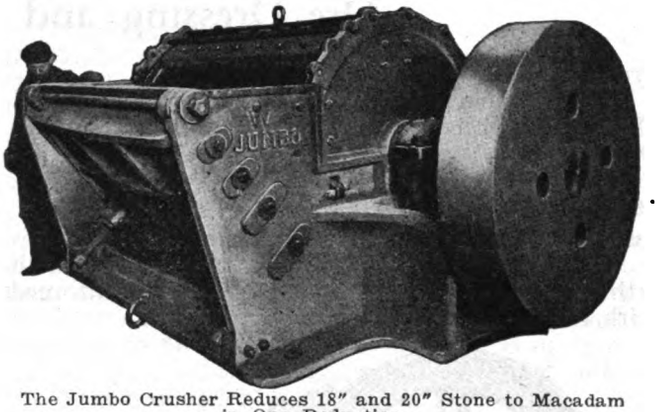
Reduces limestone and similar material as large as 36″ square by 4′ and 5′ long to 1½″ and finer in one reduction, thereby taking the place of a preliminary crusher and two or three secondary units as well as the necessary elevators and conveyors for carrying the rock through the successive crushing steps. The size of the crushed material can be regulated to suit operator's wishes. Macadam, limestone for burning, fluxing and many other grades of crushed rock can be made with the same Mammoth Crusher. The size of the finished product is variable by using grate bars with larger or smaller openings—by rearrangement of the hammers and by raising or lowering the breaker plate.



Mammoth Crusher With Cover Removed. Reduces 36″ Limestone to Macadam in One Operation.

The Jumbo Crusher

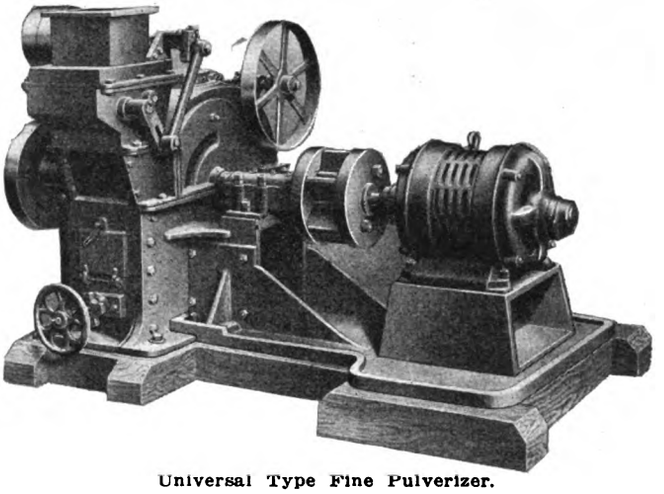
This type is widely used in cement plants, lime plants and other operations as a secondary unit to jaw or roll crushers, reducing the product of the largest size crusher to 1½″ and finer in one operation. It will also handle stone as large as 18″ and 20″, crushing it as fine as agricultural size if desired. All Williams Hinged Hammer equipment is adjustable as regards size of crushed material. Where a uniform product with a minimum of undersize or oversize goods is required, as in the making of macadam, very good results have been obtained. The Jumbo is built in eleven sizes.



The Jumbo Crusher Reduces 18″ and 20″ Stone to Macadam in One Reduction.

The Williams Hinged Hammer Pulverizer

The Universal Type is especially adapted to 16, 20, 30 and 40 mesh grinding and finer and will give this product without the aid of outside separation on dry material by reason of its many features of adjustment. It is a very economical mill to operate and the upkeep cost is exceedingly low. Widely used in the reduction of kaolin, pumice, fullers earth, plaster and similar goods, also widely used in cement plants pulverizing 1½″ and 2″ limestone to 95% 20 mesh for tube mill feed. Built in capacities of 500 pounds to 30 tons per hour.



Universal Type Fine Pulverizer.

Crushers and Pulverizers for Every Use

The Williams Patent Crusher & Pulverizer Company are the originators and inventors of the Hinged Hammer Principle and build over 300 types and sizes of crushers and pulverizers. Prices, printed matter and suggestions on the proper equipment for your work gladly submitted. You are also invited to take advantage of the Williams Engineering Department.

Complete Plants

Complete plants designed, erected and equipped for the crushing and pulverizing of any material.

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Worthington Pump and Machinery Corporation

Executive Offices
115 Broadway, NEW YORK

For List of Works and Offices, See Page 493

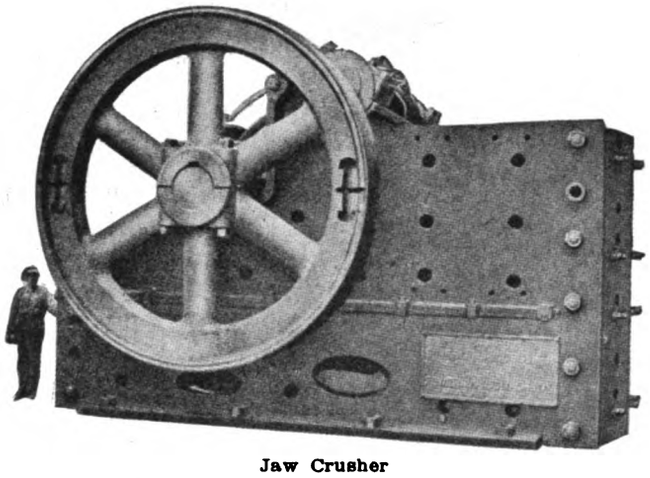
Ore Dressing and Milling Equipment

Products

Jaw Crushers; Gyratory Crushers; Cylindrical Mills; Tube Mills; Screens; Stamp Mills; Sampling Devices; Log Washers; Rolls; Jigs; Pumps for all purposes. For other products see Pages 165, 166, 167, 176, 463, 493 and 741.

Superior Jaw Crushers

Made in sizes from 7″ x 10″ to 84″ x 66″, with either cast steel or semi-steel frame, reinforced with forged steel rods.



Jaw Crusher

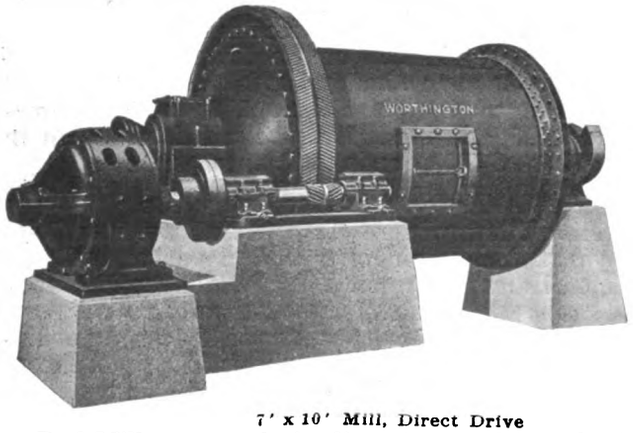
Gyratory Crushers

Made in the Superior McCully type with feed openings from 8″ to 72″, and in Standard McCully from No. 1 to No. 11 inclusive. See page 363 in Open Cut Section for illustration.

Cylindrical Mills

Worthington makes Ball Mills in all diameters and lengths with any type of lining or drive.

Tube Mills can be furnished in any diameter or length and for any drive desired.



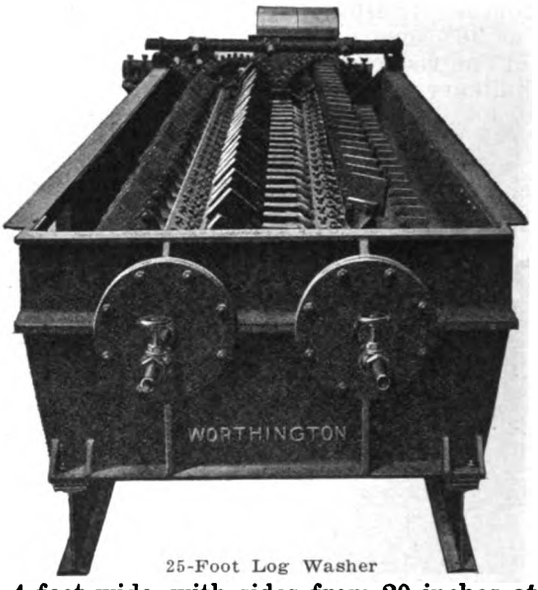
7′ x 10′ Mill, Direct Drive

Rod Mills are made in diameters and lengths to suit conditions.

Revolving Screens can be furnished for either dry or wet screening, in diameters from 24″ to 84″.

Log Washers

Worthington can furnish these machines of diameters to meet the conditions of the particular case. The standard machines are about 25 feet



25-Foot Log Washer

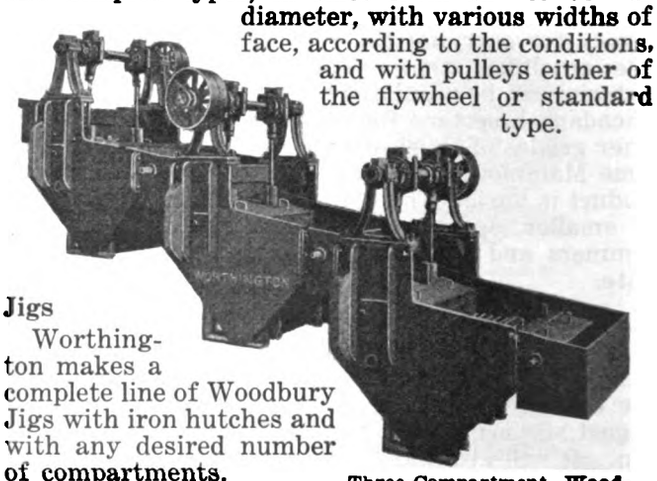
long, 4 feet wide, with sides from 20 inches at the upper end to 36 inches at the lower end.

Sampling Devices

Worthington is prepared to furnish Sampling Devices of all kinds.

Rolls

Worthington makes Rolls in Garfield, Superior and Simplex types, in sizes from 12″ to 78″ in diameter, with various widths of face, according to the conditions, and with pulleys either of the flywheel or standard type.



Jigs

Worthington makes a complete line of Woodbury Jigs with iron hutches and with any desired number of compartments.

Three-Compartment Woodbury Jigging Unit

Also a full line of Hartz Jigs, with either wood or iron hutches.

Pumps

Of all types, steam, power, centrifugal, and also the "Antisell" Acid Pump, which is used with very active acids, being lead lined with open "boot" section that is suitable for heads up to 50 feet.

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THE BRAUN CORPORATION

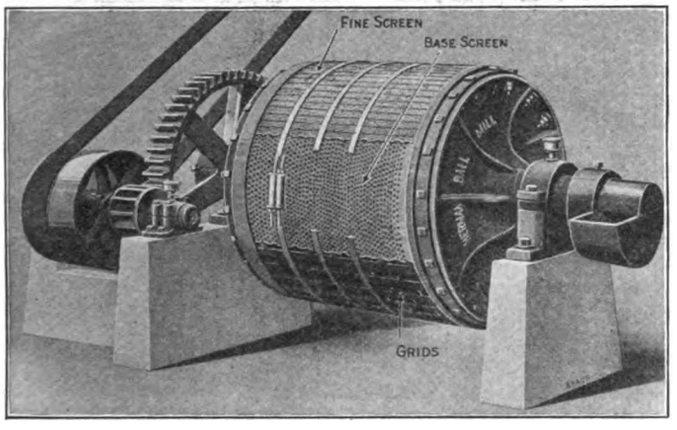
LOS ANGELES, CALIFORNIA, U. S. A.

San Francisco House: BRAUN-KNECHT-HEIMANN-COMPANY

Manufacturers of Grinding Machinery

Herman Screening Ball Mill

The Herman Screening Ball Mill is the latest modern scientific development in grinding machinery. Worthily constructed—thoroughly tested—and can be depended upon to give continuous day in and day out service. **Positively will not clog.**



Herman Screening Ball Mill (Patented March, 1916)

The shell of the Herman Mill is composed regularly of three parts: Innermost is a sectional lining of reversed grizzly grids of **Manganese Steel,** surrounding the grids is a punched metal screen of 3/16″ boiler sheet in two sections carefully rolled to correct circle, providing a smooth exterior surface, which is encircled by the fine or finishing screen, provided with end pull take-ups. Heavy felt gaskets under the end bands keep the mill leak-proof, so that discharge is confined solely to the meshes of the screen. **There is no oversize in the Herman discharge.**

Uses

The Herman Screening Ball Mill has a wide application for either wet or dry grinding, for reducing ores for amalgamation, cyanidation, flotation, concentration, etc. It grinds uniformly. Its industrial uses are wide, in fact, wherever there is grinding to be done, and the material is of such a nature as to allow screening, the Herman mill is the most economical and efficient machine.

A test plant is maintained in Los Angeles, California, where actual tests at any required mesh can be made.

Ball wear on grinding quartz to 40-mesh slot, previously crushed to ¾″, was found to be two-thirds pound per ton of 2000 pounds. Lining wear on above duty, less than 1 ounce per ton. Screens wear from 30 to 90 days under varying conditions.

Special Mills

For pottery and allied trades where products must be ground iron free, the Herman Ball Mills are made with porcelain linings, preserving the peripheral discharge feature.

The Herman Mills may also be sectionalized for mule-back transportation, where the heaviest piece can be made to any desired weight. Prices on application.

THE SCREEN ANALYSIS

The following screen analysis shows comparative results with an enclosed ball mill and the Herman Screening Ball Mill, working on the same material where the product required was minus 35 mesh.

	On 8	10	14	20	28	35	48	65	100	150	200	Through 200
End Discharge Ball Mill	1.0%	2.4%	5.2%	9.6%	11.8%	10.6%	8.8%	8.4%	7.4%	6.0%	5.0%	23.8%
Herman Ball Mill Discharge	0%	0%	0%	0%	0%	0%	30.0%	20.1%	14.8%	10.2%	7.4%	17.5%

A corresponding superiority of the Herman Mill is shown at coarser or finer meshes.

TABLE OF DETAILS FOR STANDARD HERMAN SCREENING BALL MILLS

Power listed is for mill alone. Surplus power for auxiliaries must be allowed for extra. Capacities given below are based on ¾″ feed.

Capacity in tons to 40 mesh slot in 24 hrs.	3*	10	20	40	70	110	110	225
Shell length, feet	1¼	1¼	2½	2½	2½	2½	4	5
Shell diameter, feet	2	3	3	4	5	6	5	6
H. P. to start	2	5	8	15	20	40	40	80
H. P. to operate	2	3	5	10	15	25	25	50
Speed, r. p. m.	36	30	30	26	24	22	24	22
T. & L. pulley size, inches	42x6	20x6	20x6	40x6	40x10	60x12	60x12	72x12
Approximate weight of ball charge, pounds	400	900	1800	3200	5000	7200	7200	14,400
Shipping weight, pounds	1400	2400	3000	4500	6500	8000	8000	12,000
Code Name	MILOK	MILUB	MILOC	MILET	MILIS	MILED	MILAC	MILAP
Each, without balls	$400.00	$800.00	$1100.00	$1600.00	$2100.00	$2700.00	$2700.00	$4000.00
Renewal Parts								
Manganese Steel Grids	$100.00	$150.00	$250.00	$350.00	$500.00	$750.00	$875.00	$1400.00
Chrome Alloy Head Liners	$100.00	$150.00	$150.00	$300.00	$500.00	$750.00	$500.00	$750.00

*Pulley drive only.

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HARDINGE COMPANY

120 Broadway, NEW YORK

SALT LAKE CITY, UTAH.....Newhouse Building
LONDON, ENGLAND....11-13 Southampton Row

Works
YORK, PA. ERITH, ENGLAND

Conical Ball and Pebble Mills

Products

Manufacturers of the Hardinge Conical Ball and Pebble Mill for grinding and pulverizing. Engineers for design and construction of metallurgical and industrial plants.

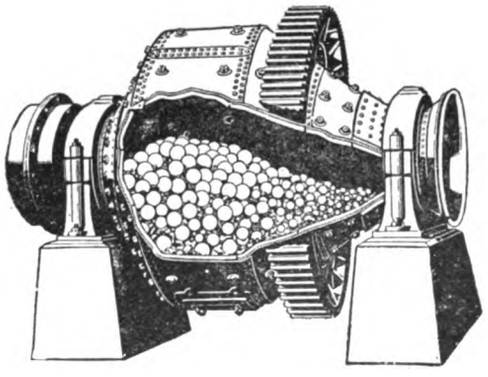
Uses

The Hardinge Conical Mill grinds both wet and dry ores for metallurgical processes and materials for industrial uses, from a maximum size of three inches to a product of any degree of fineness. Some of the materials ground are:

Gold Ores	Silica	Coal
Silver Ores	Barytes	Cement Clinker
Copper Ores	Pigments	Limestone
Lead Ores	Mica	Phosphate Rock
Zinc Ores	Sulphur	Feldspar
Tungsten Ores	Foundry Waste	Carborundum

Principle of Operation

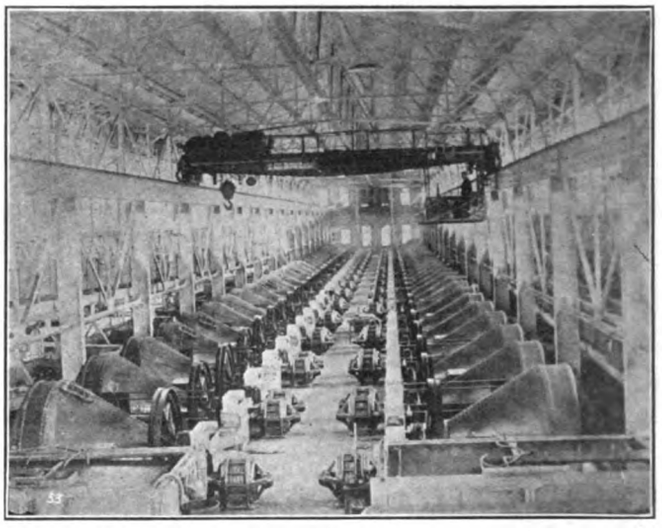
The Hardinge Conical Mill operates on the principle of multiplicity of grinding bodies rotated in a conical drum. These bodies, in dropping, crush and grind the material passing through the mill. In the conical mill there exists the logical law of pulverization, i. e., in stages. The large material on entering the mill is crushed by the large balls or pebbles which always remain near the feed end (largest number), due to the classifying action of the cone, and as this partially reduced material



How Balls Segregate During Operation of a Hardinge Conical Mill

travels forward it is further ground by the smaller grinding media, and so on until it is discharged at the apex of the cone. The effect of such an action is to proportion the energy to the work required, or in other words, "Use a sledge hammer to drive a spike and a tack hammer to drive a tack." To grind fine material with large balls or pebbles is a waste of energy and to try to crush large feed with small grinding media is futile. This latter action does occur where no natural segregation exists, as in the conical mill.

The net result of this principle is: (A) Action within the conical mill in proportioning the energy to the work performed saves power. (B) A greater range of grinding is made possible as different sizes are roughly segregated and do not interfere with one another. (C) The capacity of a given size of unit is increased since the ground material is actually forced forward by the classifying effect of the discharge cone. (D) Wear is greatly reduced, as less grinding media are required to effect a given production, and those that are used do effective work, which saves the lining as well. (E) The conical shape insures extreme rigidity and simplicity of construction. Mechanical troubles during operation are almost unknown. Labor costs are next to nothing.



Sixty-Four 8 Ft. Diameter Hardinge Conical Mills Operated By Two Men Per Shift

Application to Metallurgical Processes

Table Concentration—Product where minimum of fines is desired, ranging in fineness between 16 and 35 mesh.

Flotation—Product desired where ore is ground so that maximum amount of mineral is freed from gangue, ranging in fineness from 48 to 100 mesh.

Cyanidation—Product desired where ore is ground as fine as is consistent with economical operation. Fineness ranges between 100 and 200 mesh.

Amalgamation—Product desired where fineness ranges between 35 and 100 mesh.

Pulverized Fuel—Product desired for burning, where a maximum of fines is desired, usually from 80 to 95 per cent. passing 200 mesh.

Application to Industrial Processes

Most industrial requirements call for material to be ground dry. Where a closely sized product is desired, vibrating screens or air separators are used in closed circuit with the mill, making a very satisfactory self-contained unit, free from excessive wear, which is so often prevalent in other methods employed in this field.

Information Required

1. Name and address.
2. Character of material.
3. Grinding capacity in tons per hour.
4. Maximum size to be fed Hardinge Mill.
5. Fineness of product desired.
6. Grinding wet or dry.
7. Subsequent process.

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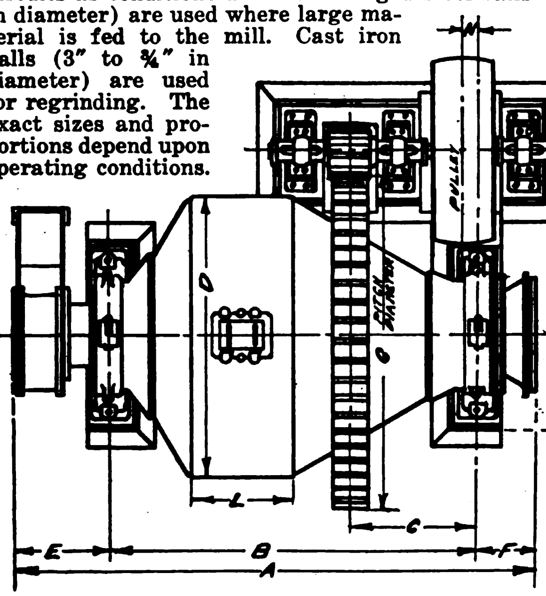
The Hardinge Conical Ball Mill

This type has become very popular within the last few years owing to the large range of reduction possible and large capacity per unit. It is used either in single stage or two-stage grinding processes, grinding in open or closed circuits as conditions demand. Forged steel balls (5" to 2" in diameter) are used where large material is fed to the mill. Cast iron balls (3" to ¾" in diameter) are used for regrinding. The exact sizes and proportions depend upon operating conditions.



Type "B" Hardinge Conical Mill

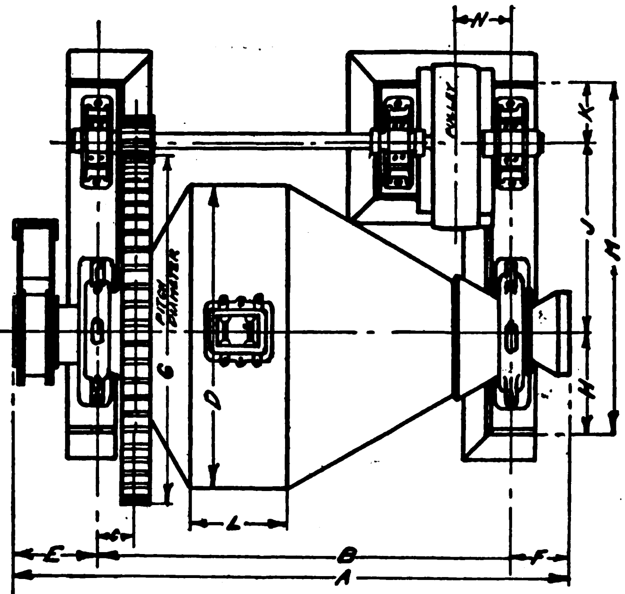
SPECIFICATIONS AND CAPACITIES OF CONICAL BALL MILLS

Size of Mill	Floor Space	Approximate Weights, Pounds: Mill	Lining	Ball Chg.	H.P. to Run	Size of Motor H.P.	Capacity in Tons Per Hour: mesh 1½"to 8	1½" to 48 mesh	½"to65 mesh	Code Word
3' x 8"	5'x 7'	3800	1400	1000	5	7½	¾	⅓	⅓	Bolus
4½'x16"	7'x10'	6600	4800	4500	18	25	2	1	1⅓	Bomdu
5' x22"	9'x10'	10200	7800	7500	30	35	3	2	2½	Bonhu
6' x22'	10'x11'	12000	10000	12000	45	50	6	4	5	Boots
7' x22"	11'x12'	14000	14000	20000	70	75	10	7	8	Botun
7' x36"	11'x13'	15000	16300	27000	90	100	12	8	9½	Bounc
8' x22"	12'x14'	20300	17700	30000	100	100	14	9½	11	Cabma
8' x36"	12'x14'	22000	19400	34000	135	150	18	14	16	Caciq
8' x48"	12'x15'	27400	22600	38000	170	175	24	19	21	Cactu
9' x48"	13'x16'	35000	30000	53000	230	250	33	26	29	Caddi
10' x48"	13'x16'	40000	35000	68000	300	350	45	35	38	Cadut

The capacities shown are based upon ores of medium hardness. Since every ore varies in its resistance to grinding, the capacities under a given condition will likewise vary. Therefore, this table must be considered as an approximation.

The Hardinge Conical Pebble Mill

This type is particularly adapted to table concentration where uniform product is desired, also where the cost of operating a ball mill would exceed that of the equivalent pebble mill. This is usually the case where a very fine product is required. Grinding is then done in open or closed circuit, depending upon operating conditions. Flint pebbles (5" to 1" in diameter) are used as grinding media. The sizes and proportions depend upon operating conditions.



Type "A" Hardinge Conical Mill

SPECIFICATIONS AND CAPACITIES OF CONICAL PEBBLE MILLS

Size of Mill	Floor Space	Approximate Weights, Pounds: Mill	Lining	Ball Chg.	H.P. to Run	Size of Motor H.P.	Capacity in Tons Per Hour: ½"to 28 mesh	½"to48 mesh	8 mesh to 200 mesh	Code Word
3' x 8"	5'x 7'	3800	1500	300	3	5	⅓	¼	⅛	Bomba
4½'x16"	7'x10'	6600	3500	2500	8	10	1	⅔	⅓	Bonan
5' x22"	8'x11'	10200	4500	3500	12	15	1⅓	1	½	Bonne
6' x22"	9'x11'	10000	7500	4500	18	25	2⅓	1⅔	1	Boppa
6' x48"	9'x13'	12000	9000	5500	27	35	3	2½	1⅓	Borou
7' x30"	10'x13'	13000	10000	9000	35	50	4	3⅓	1⅔	Boubh
7' x48"	10'x14'	14000	12000	10000	40	50	4⅓	3⅔	2	Bovin
8' x36"	11'x15'	16000	16000	12000	55	60	7	5	2½	Cackl
8' x48"	11'x16'	17000	20000	14000	65	75	8⅓	6	3	Cadve

The capacities shown are based upon ores of medium hardness. Since every ore varies in the resistance to grinding, the capacities under a given condition will likewise vary. Therefore, this table must be considered as an approximation.

GENERAL DIMENSIONS OF CONICAL BALL MILLS

The Standard Ball Mill is of Type "B" Construction

Size of Mill	A	B	C	D	E	F	G	H	J	K	L	M	N	Size of Main Bearing
3'x8"	6'-4¾"	4'-0¼"		3'-2"	1'-6½"	0'-10"		1'-9"			8"			10" Diam.
4½'x16"	9'-10"	6'-7"	1'-9½"	4'-6"	2'-0¾"	1'-2¼"	5'-0"	2'-1½"	2'-6¾"	1'-11"	16"	6'-7¼"	11½"	13" "
5'x22"	9'-10½"	6'-7½"	1'-11¼"	5'-0"	2'-0¼"	1'-2¾"	6'-0"	2'-4½"	3'-2"	1'-5"	22"	6'-11½"	13¼"	23" "
6'x22"	10'-11¾"	7'-10"	2'-4⅝"	6'-0"	1'-10"	1'-3¾"	7'-0"	2'-4½"	4'-0¼"	1'-6"	22"	7'-10¾"	15"	23" "
7'x22"	12'-0½"	8'-7"	2'-11½"	7'-0"	1'-10¾"	1'-6¾"	9'-6"	2'-9½"	5'-5¼"	1'-6"	22"	9'-8¾"	2"	28" "
7'x36"	13'-2½"	9'-9"	2'-11½"	7'-0"	1'-10¾"	1'-6¾"	9'-6"	2'-9½"	5'-5¼"	1'-6"	36"	9'-8¾"	2"	28" "
8'x22"	13'-1"	9'-5"	3'-8¼"	8'-0"	2'-3"	1'-5"	10'-0"	3'-1½"	5'-4½"	1'-8"	22"	10'-2"	12"	33" "
8'x36"	14'-3"	10'-7"	3'-8¼"	8'-0"	2'-3"	1'-5"	10'-0"	3'-1½"	5'-4½"	1'-8"	36"	10'-2"	12"	33" "
8'x48"	15'-3"	11'-7"	3'-8¼"	8'-0"	2'-3"	1'-5"	10'-0"	3'-1½"	5'-4½"	1'-8"	48"	10'-2"	12"	33" "
9'x48"	15'-6"	11'-5"	3'-8¼"	9'-0"	2'-5"	1'-8"	11'-0"	3'-1½"	5'-7"	1'-8"	48"	10'-4½"	15"	33" "
10'x48"	16'-2"	12'-6"	4'-2"	10'-0"	2'-10"	1'-10"	11'-6"	3'-1½"	5'-8½"	1'-8"	48"	10'-6"	18"	33" "

GENERAL DIMENSIONS OF HARDINGE PEBBLE MILLS

The Small Standard Pebble Mills are of Type "B" Construction, While the Large Standard Pebble Mills are of Type "A" Construction

TYPE "B" PEBBLE MILLS

Size of Mill	A	B	C	D	E	F	G	H	J	K	L	M	N	Size of Main Bearing
3'x8"	6'-4¾"	4'-0¼"		3'-2"	1'-6½"	0'-10"		1'-9"			8"			10" Diam.
4½'x16"	9'-10"	6'-7"	1'-9½"	4'-6"	2'-0¾"	1'-2¼"	5'-0"	2'-1½"	2'-6¾"	1'-11"	16"	6'-7¼"	11½"	13" "
5'x22"	9'-10½"	6'-7½"	1'-11¼"	5'-0"	2'-0¼"	1'-2¾"	6'-0"	2'-4½"	3'-2"	1'-5"	22"	6'-11½"	13¼"	23" "
6'x22"	10'-11¾"	7'-10"	2'-4⅝"	6'-0"	1'-10"	1'-3¾"	7'-0"	2'-4½"	4'-0¼"	1'-6"	22"	7'-10¾"		23" "
6'x48"	13'-1¾"	10'-0"	2'-4⅝"	6'-0"	1'-10"	1'-3¾"	7'-0"	2'-4½"	4'-0¼"	1'-7"	48"	7'-11¾"		23" "

TYPE "A" PEBBLE MILLS

7'x30"	12'-8½"	9'-6¼"	12¾"	7'-0"	1'-10½"	1'-3¾"	8'-0"	2'-4½"	4'-6½"	1'-5"	30"	8'-4"	1'-6"	23" "
7'x48"	14'-2½"	11'-0¼"	12¾"	7'-0"	1'-10½"	1'-3¾"	8'-0"	2'-4½"	4'-6½"	1'-5"	48"	8'-4"	1'-6"	23" "
8'x36"	14'-6¼"	11'-4"	12¾"	8'-0"	1'-10½"	1'-3¾"	9'-0"	2'-4½"	5'-0"	1'-5½"	36"	8'-10"	1'-6"	23" "
8'x48"	15'-6¼"	12'-4"	12¾"	8'-0"	1'-10½"	1'-3¾"	9'-0"	2'-4½"	5'-0"	1'-5½"	48"	8'-10"	1'-6"	23" "

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JOSHUA HENDY IRON WORKS

ESTABLISHED 1856

General Office
75 Fremont Street, SAN FRANCISCO, CALIFORNIA
Works—Sunnyvale, Santa Clara Co., California, U. S. A.
Manufacturers of

Mining and Ore Reduction Machinery

Contractors for the design and construction of complete plants

Products

Stamp Mills, Ball Mills, Rod Mills, Tube Mills, Centrifugal Mills, Crushing Rolls, Ore Dressing Machinery, Oil Flotation Machinery, Jaw and Roller types of Ore and Rock Breakers, Ore Concentrators, Rotary Kilns and Ore Dryers, Revolving Screens for every purpose, Log Washers, Jigs, Feeders, Conveyors and Elevators, Quick-silver Furnaces, Quick-silver Retorts, Etc., Etc. For other products see pages 360, 401, 528, 529, 631.

"Pioneer" Mill

HENDY QUARTZ STAMP MILLS
With Single and Triple Discharge Mortars

The "Pioneer" Mill

Two-Stamp, Self-Contained Iron and Steel Mill for Prospectors, Assayers or Colleges.

Compact crushing unit having single issue mortar and two stamps; for prospecting and Assay Offices where mill tests are desired and for economically reducing high grade ore in small quantities.

Preferable to large mills for demonstrations in Schools and Colleges on account of its greater convenience for analytical or class observation.

Weight of Mill	2900 lbs.
Weight of Stamps	300 lbs.
Capacity	300 lbs. per hour
Power Required	Less than 2 H. P.
Code Word	KOPERIG

The "Crescent" Mill

A Two-Stamp Quartz Mill having a single Elliptical Discharge, with Enlarged Screen Area. Popular because of its simplicity.

Cast or Chrome Steel Cams, Tappets, Bossheads, Shoes and Dies, Steel Stems, Patent Guides, Sugar Pine Built-up Battery Pulley, Steel Camshaft, Heavy Boxes, Stem-feed-Collar, Jackshaft, Boxes and Fingers.

Battery Frame made of well-seasoned Oregon Pine bolted to mortar. Guide Girts are mortised and tenoned and bolted to insure rigidity and compactness.

Weight of Stamps	680 lbs. each
Total Shipping Weight	8,100 lbs.
Heaviest Single Piece	1250 lbs.
Power Required	5 H. P.
Code Word	KOPERKIES

"Crescent" Mill

Hendy's Two-Stamp Mill (Triple Discharge Mortar)

Hendy Original Two-Stamp Mill

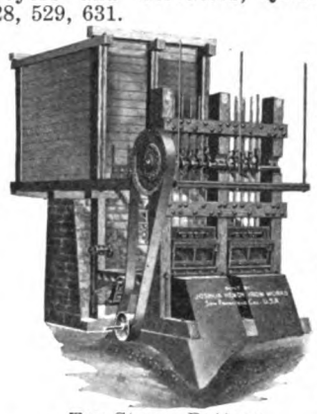
Triple discharge Mortar. The Original Two-Stamp Mill having 850 and 1000 lb. stamps, of which more than 1000 have been sold since 1895. Small enough for a prospecting mill; substantial in design; capacity sufficient to warrant installation in a battery of two or three units for permanent work for a small mine. Equivalent in all details of design to our standard mills. Can be made as profitable as mills of five or more stamps.

Combined area of three outlets—60 square inches—more than the average of standard five-stamp mortars.

Capacity, using 1000 lb. stamps, 1" to 1½" feed, 4 to 6 tons per stamp per 24-hour day.

Power required, 5 to 6 H. P.

Code Word—KOPERKLEUR.



Ten-Stamp Battery Mounted on Concrete Mortar Blocks

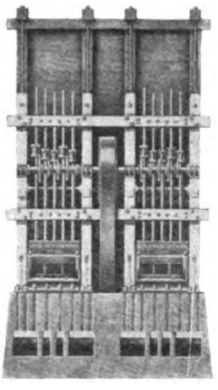
Five-Stamp Batteries

A Ten-Stamp Battery on concrete mortar blocks, having a back-knee frame, which is less costly, simpler and more sensible than the earlier "A" type frames. The ore bin forms an effective anchor for the battery frame proper, sitting on the back-knee beam, eliminating any front bracing. They may have angle or flat bottom, according to the purchaser's ideas.

We furnish designs and instruction to purchasers, when required, as to the construction of mortar blocks. These are unaffected by climatic conditions, do not decay, and should last a lifetime.

Four-Post Type of Battery

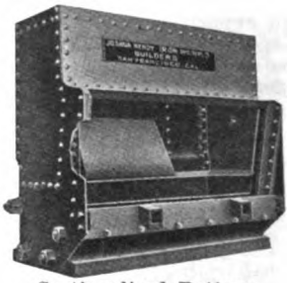
Advantages offset greater cost. Comparative immunity from broken cam-shaft; half the usual strain on the cam-shaft, due to the position of the pulley between the two batteries. We recommend its use in preference to any other type of frame.



Four-Post Type of Battery

Sectionalized Mortars

Built with the utmost care and attention. Each part weighs less than 300 lbs. Height over all, 4 ft. 4 in.



Sectionalized Battery Mortar

Feed Opening, 5¼ in. wide, 28 in. long. Fitted with a complete set of inside liners, including feed opening liner, discharge liner and back and two end liners.

Approximate shipping weights: Mortar, for wood-block foundation, 5,000 lbs.; Mortar for concrete block foundation, 6,250 lbs.

Hendy's Two-Stamp Mill. Same as shown to left but built in sections

Hendy Original Two-Stamp Mill Built in Sections

For Mountain Transport. Built in sections, so that the heaviest piece does not exceed 300 lbs. in weight, except the stems, which weigh about 350 lbs., and the camshaft, which is 5 in. in diameter by 5 ft. 2½ in. long, and weighs 345 lbs. Frame is usually hewn from rough timber obtained locally. When desired the cam-shaft can be made "sectional" in halves at additional cost.

Code Word—KOPERMOLEN.

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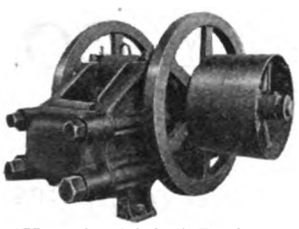
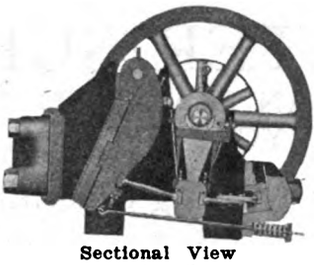


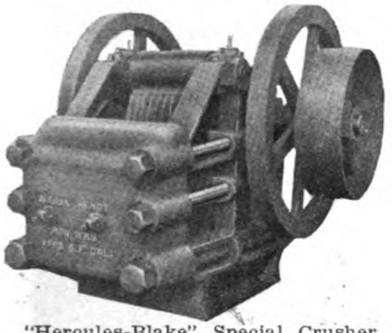
"Hercules-Blake" Rock or Ore Crusher—(Type B)



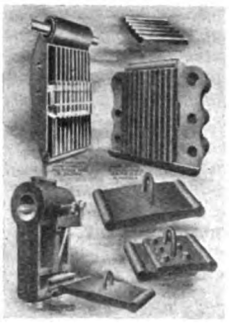
Sectional View

"HERCULES-BLAKE" CRUSHERS—SPECIFICATIONS

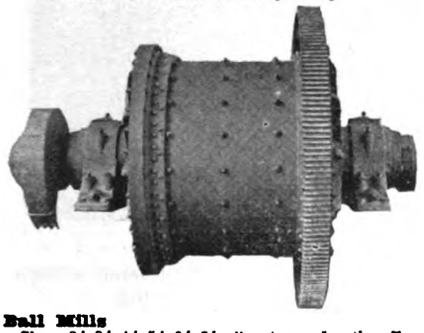
	No. 1	No. 2	No. 3	No. 4
Size of Jaw Opening, In...	6x7½	7x9	8x12	10x16
Capacity, Tons per Hr....	3	4	6	10
Horsepower	4	5	8	12
Weight, Heaviest Piece, Lbs.	310	435	600	1310
Total Weight, Lbs.....	2700	3500	5860	10,200



"Hercules-Blake" Special Crusher (Type B) Built for extra heavy duty

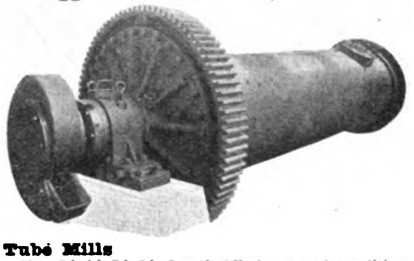


Sectional, interlocking, interchangeable, adjusting die and shoe; toggle seat and shear toggle.



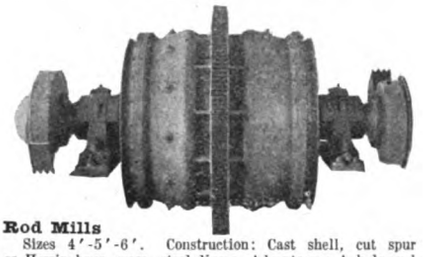
Ball Mills

Sizes 2'-3'-4'-5'-6'-7' diameters. Lengths: Various to suit conditions. Construction: Boiler plate shell, semi-steel heads. Cut spur or Herringbone gears. Rapid discharge head; chrome steel liners.



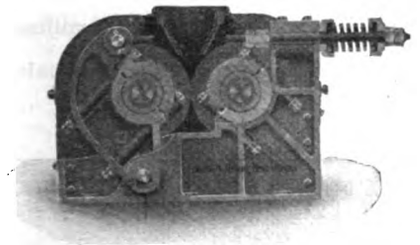
Tube Mills

Sizes 3'-4'-5'-6'. Lengths: Various to suit conditions. Construction: Boiler plate shell, semi-steel heads. Cut spur or Herringbone gears. Rapid discharge head; chrome steel liners.

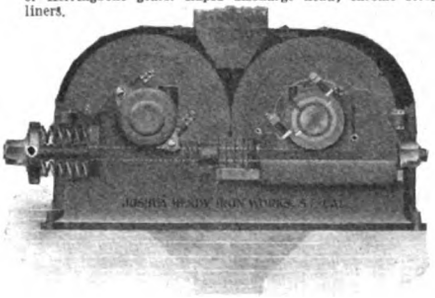


Rod Mills

Sizes 4'-5'-6'. Construction: Cast shell, cut spur or Herringbone gears, steel liners. Advantages: A balanced mill, resulting in low horse power consumption. Capacity: About 50% more per horse power input over any other type of ore grinding mill. Grinds wet or dry. Feeds either or both ends. Discharges peripherally on both ends.



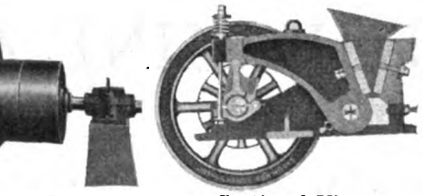
Crushing Rolls, Class "B"



Crushing Rolls, Class "A"

SPECIFICATIONS CLASS "A" AND CLASS "B" CRUSHING ROLLS

Class	Code Word	No.	Size of Rolls Dia. Inches	Width Inches	Size of Rigid Roll Pulley Ins.	Size Adjustable Roll Pulley Inches	Weight Heaviest Piece Pounds	Total Shipping Weight Pounds	Weight Feeder Extra Pounds	Capacity in Tons per hour 16 to 4 Mesh	Rev. per Minute	H. P. Required
A	Ebur.	1	20x	8	60x 8	30x 6	1015	6,700	175	1 to 5	100-150	3 to 6
A	Edax.	2	20x	12	60x10	30x 8	1050	7,100	175	1½ to 6	100-150	4 to 8
B	Edent	3	27x	12	60x12	30x 8	2200	12,000	175	2 to 7	75 to 125	5 to 10
B½	Edible	4	30x	14	72x12	36x 8	2500	14,000	175	2½ to 8	65 to 85	8 to 15
B	Edin	5	36x	16	84x16	42x10	7000	24,000	175	3 to 9	50 to 75	10 to 20

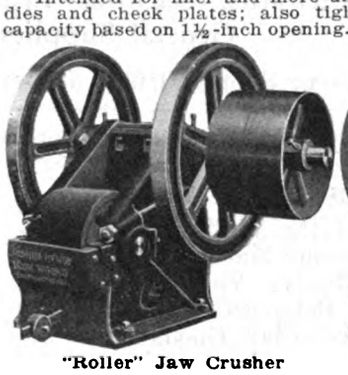


"Dodge" Ore and Rock Breaker

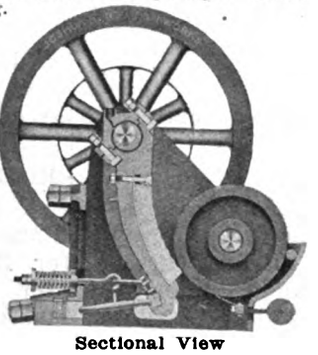
Sectional View

Dodge Crushers

Intended for finer and more uniform crushing. Steel shoes, dies and cheek plates; also tight and loose pulleys. Rated capacity based on 1½-inch opening.



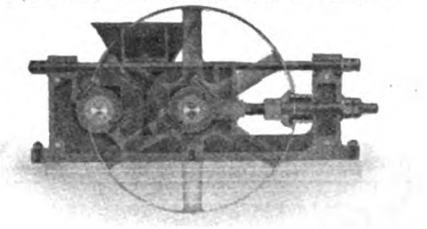
"Roller" Jaw Crusher



Sectional View

"Roller" Jaw Crushers

The above illustrates our design and make of the "Roller" Jaw Crusher. Its principal advantage is its adaptability for working wet or sticky ores, or where fine crushing is desired. The movable jaw to which is attached the shoe is mounted upon a revolving eccentric shaft. The ore being crushed between the shoe and revolving die, causes the die to make a slight forward movement at each stroke; backward movement is prevented by a roller placed between the roll die and the frame. Arrangement is made for setting up shoe as it wears, or for fine crushing. A scraper, cleaning the entire width of roll, is regulated by a lever and weight. Double fly wheels are used, fitted with slipping keys; also tight and loose pulleys.



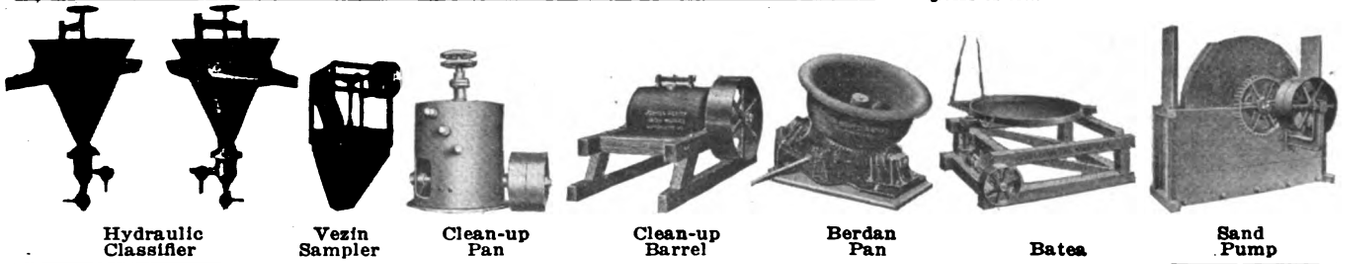
Crushing Rolls for Fine Grinding

"SPECIAL" RE-CRUSHING ROLLS—SPECIFICATIONS

Number	10
Size	16x10
Size of Driving Pulleys	36x8½
Weight of Heaviest Piece	550
Total Weight	3400
Capacity in Tons per Hr. 4 to 40 Mesh	1½—2
Revolutions	150-200
Horsepower Required	3 to 6

Length, 5'8"; Width, 4'1"; Height above base 2'3".

Code Word: EDISMA—Fitted with steel shells turned on face. EDITUS—Fitted with chilled iron shells ground on face. EDOLAT—Fitted with chilled iron shells not ground on face.



Hydraulic Classifier | Vezin Sampler | Clean-up Pan | Clean-up Barrel | Berdan Pan | Batea | Sand Pump

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THE MINE & SMELTER SUPPLY CO.

DENVER SALT LAKE SAN FRANCISCO EL PASO
42 Broadway, NEW YORK CITY

Ore Dressing and Milling Machinery; Mining Machinery and Supplies

Machinery, Apparatus, Scientific Instruments, Chemicals, Electrical Goods, General Supplies and Equipment

Large Supply Depots at Denver, Salt Lake City, El Paso

Complete bulletins published for each of the following principal products, in addition to large general catalogs of Mill Supplies, Electrical Goods, and Assayer's and Laboratory Equipment and Supplies.

PRODUCTS

Sole manufacturers of the Wilfley Concentrating Table, Marcy Ball Mill and Marcy Roller Mill.

Selling agents for Dourte Valveless Pumps, Sand Pumps, Heusser Balances, Samson Laboratory Crushers, Massco Clay Goods and Furnaces, Pierce Amalgamators, Murray Corliss Engines, Murray Water Tube and Internal Feed Boilers, H.S.B.W. Cochran Corporation Open Type Feed Water Heaters and Water Systems, Erie Ball Engines.

THE WILFLEY TABLE FOR CONCENTRATION

More than 23,000 Wilfley Concentrating Tables in use in the largest plants all over the world testify to the enormous success and deserved popularity of this table.

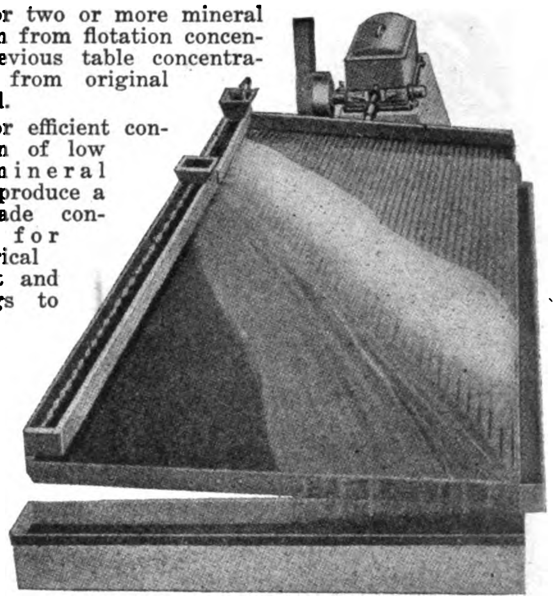
The table is a mechanically operated end-wise reciprocating table consisting of a self-oiling enclosed type of head motion, a deck having a plain surface partly riffled and partly unriffled and an understructure and tilting device.

It separates the heavy and the light grains of material into bands; it handles the finest slimes or the coarsest sands with excellent results; it is capable of dressing any ore or material subject to concentration.

Recommendations as to Uses

The following are a few of the concentration operations in which the Wilfley Concentrating Table has proved its superiority:

1. Before or after flotation units for the recovery of coarse mineral not readily recovered by flotation.
2. As pilot tables following flotation machines as an indicator to the operator as to the efficiency of each flotation unit, and for the recovery of valuable mineral when the flotation unit is not working at a high recovery of mineral. Wilfleys used as pilot tables give the operator instant warning of inefficient flotation operation.
3. For two or more mineral separation from flotation concentrate, previous table concentration, or from original table feed.
4. For efficient concentration of low grade mineral feeds to produce a high grade concentrate for metallurgical treatment and a tailings to waste.



A Wilfley in Action

5. For concentrating a middlings feed producing a high grade concentrate and a middlings for regrinding.
6. For the concentration of mineral feeds of low specific gravity, such as graphite, molybdenum, etc.
7. For the recovery of metallics, etc., from refuse in brass foundries, cyanide plants, assay offices, and remelting and casting works.
8. As a means of controlling classification in milling plants under certain conditions.
9. For the washing and cleaning of inferior coals, iron ores, etc.

WILFLEY DATA

General information on the different sizes and types of Wilfley Tables as regards weights, pulleys, size deck, etc.

TABLE	Capacity Tons 24 Hours	Operating Horsepower	Usual Speeds	Water Gal.-min.	Pulleys Diameter and Face	Weight Domestic	Weight Export	Cu. Dim. Pkd. for Export, Cu. Ft.	Weight Heaviest Piece or Pieces Packed for Export	Stroke in Inches	Size of Deck	Type of Under-structure
No. 6	15-50	½-¾	240-290	5-20	14x4	3100	3400	141.7	835	½-1	5′11″x14′ 9″	Steel Frame
No. 6 Special	10-40	½-¾	240-290	5-20	14x4	3000	3300	130	675	½-1	5′ 3″x12′10½″	Steel Frame
No. 9	20-80	1-1½	235-250	10-40	18x4	3600	4000	180	1130	½-1	5′ 3″x12′10½″	Steel Frame
No. 11-D, Type 6	15-50	½-¾	240-290	5-20	14x4	1850	2250	127	850	½-1	5′11″x14′ 9″	Concrete
No. 12	5-15	¼-½	240-290	3-15	14x4	2100	2400	97	300	½-1	3′ 6″x 7′	Timber Frame
No. 13	½-2	⅛-⅙	300-375	½-4	6x1	200	250	10	220	¼-½	1′1½″x2′ 6″	Steel Frame
No. 14	15-50	½-¾	240-290	5-20	14x4	2900	3300	159	890	½-1	5′11″x14′ 9″	Timber Frame

MARCY ROLLER MILLS

The Marcy Roller Mill will take a 1-inch crusher feed and in one pass of the mill will produce a very uniform product of 8, 10, 14 or 20 mesh, so essential for good table extraction. For grinding for flotation, cyanidation, amalgamation, etc., where finer grinding is desired the mill should be operated in closed circuit. This machine is especially desirable for regrinding work. The Marcy Roller Mill is a very efficient grinding machine either wet or dry.

To get the best grinding results from rods it is well recognized that we must have:

1. A heavy, slowly revolving rod mass.
2. A low pulp line or a small amount of pulp in the mill.
3. A practical way to remove broken rods worn as small as ⅝″.

The Marcy Roller Mill is made to meet these operating conditions. It is built along good engineering lines and particular attention has been given to the strength and the

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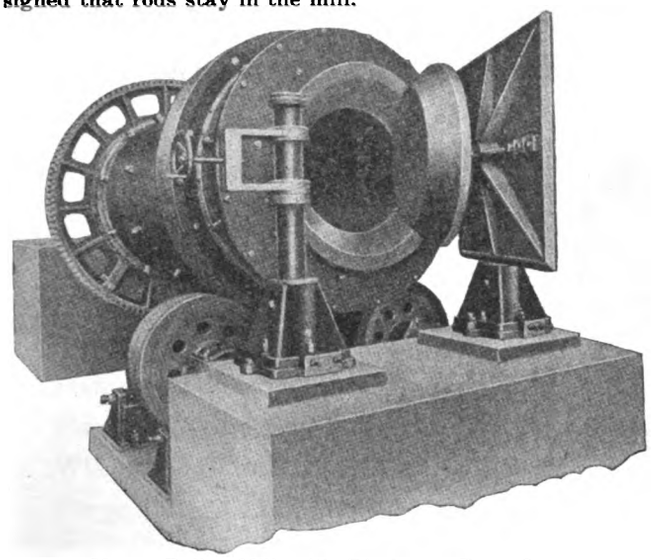
wearing qualities of the material used. It has an open end feature, by means of which a low pulp line is maintained and through which the rods can be removed and any new ones replaced with ease. All relining is done through the big opening in the discharge head of the mill. It is so designed that rods stay in the mill.



Marcy Roller Mill with Discharge Door Open

Finished pulp in a mill or ore which has been reduced to the required fineness should be discharged at once, otherwise the force of the rod mass is cushioned by the finished material in the mill. The low pulp line in the Marcy Roller Mill induces the rapid removal of finished product and also permits the carrying of a thick pulp, whereby the rods and liners are coated with particles of material which assist the contact that produces efficient grinding and greatly increases the capacity, since the rods work on thin layers of thick pulp. The Marcy Roller Mill does the greater part of its grinding by attrition instead of impact and for that reason a grinding medium of low cost can be used. Because of the door feature at the discharge end, examination can be made at any time of the interior conditions, and thus the grinding medium is kept at its highest point of efficiency. The Marcy Roller Mill is an investment that gives high returns because of low operating costs and large capacity.

MARCY ROLLER MILL SIZES

Sizest	Usual Charge Tons Rod	Horse Power to Run	Size Motor* Recommended H. P.	R.P.M. Mill	Approx. Shipping Wt., Lbs.
3'x 6'	2-2½	15-18	20	30	21,000
3'x 8'	3-4	24-28	30	30	25,000
4'x 8'	6-7	45-50	50	25	40,000
4'x10'	8-9	55-60	60	25	44,000
5'x10'	12-13	95-100	100	20	80,000
5'x12'	14-15	115-120	125	20	90,000
6'x12'	18-19	140-150	150	17	110,000
12"x24" Laboratory	300 lbs.	1-1½	1½ H.P.	35	1,100

†Other sizes to meet special conditions.
*A high starting torque motor recommended.

Marcy Roller Mills are manufactured in sizes having capacities from 20 to 1200 tons each per 24 hours depending upon size of feed, hardness of feed, size of finished product.

THE MARCY BALL MILL

The Marcy Ball Mill, which will take a 2½" feed, is a wet or dry crushing ball mill having almost the entire discharge end fitted with grates. Between the grate and the end of the mill there are arranged lifters which act as a pump to lift the product so it will be discharged through the discharge trunnion of the mill. In wet crushing the water and feed enter the mill through the feed trunnion, consequently there is a difference in elevation between the feed as it enters the mill and the point of discharge through the grate. The water, therefore, causes a sluicing action which quickly carries the fines and slimes through the grate, then to the lifters and out through the trunnion or discharge end of the mill. This method of operation relieves the mill of a bulky mass of pulp and causes the fines to migrate faster than the coarse particles. It also increases the relative weight of the balls that would otherwise be under the influence of the buoyant effect of the pulp.

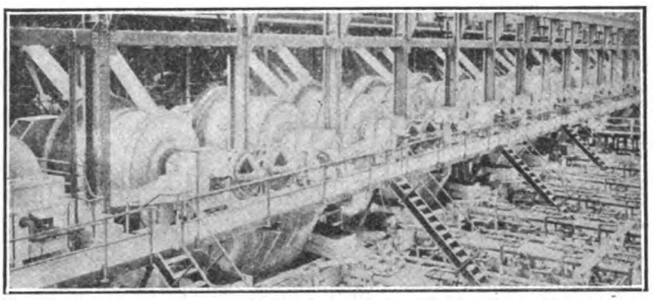
The product of the Marcy Mill is nearly non-selective. By non-selective is meant a product in which the mineral has not been subjected to a classifying action, nor has it become over-crushed as compared with the gangue. Whereas, in the operation of all classes of overflow trunnion discharge mills, there is a vertical gravity classification of the mineral from the gangue. That is, the mineral being heavier, is carried lower or next to the periphery and consequently ground into undesirable product.

Advantages of the Marcy Ball Mill

1. Large balls will break large rock, but with the first blows many sizes are made including the finest of slimes. By removing the product as fast as made, you have graded crushing and gain in efficiency. This is accomplished by the sluicing action of the water, low discharge point and the lifters back of the grates.

2. Marcy Ball Mills are charged with many sizes of balls and with the entrance of coarse feed to the mill it is soon a revolving mass, heavy, flexible and compact, in which all the interstices are filled. Under these conditions, the maximum abrasion and crushing takes place. The voids between the balls are filled with the coarse ore which is essential for maximum efficiency; coarse sizes help to grind the finer sizes. This condition is maintained in this machine because it operates about ⅓ or ¼ full of thick pulp, having a consistency of about 25% to 30% water. The liners and balls are covered with sands, thus, whenever there is moving contact, crushing results.

3. The Marcy Mills, as stated, carry a small amount of pulp, which produces a rapid circulation, thus increasing efficiency.



Largest Ball Milling Plant in the World

APPROXIMATE MARCY BALL MILL CAPACITIES

Size Mill	Tons. 24 Hrs. -8 Mesh	Tons 24 Hrs. -20 Mesh	Tons 24 Hrs. -35 Mesh	Tons 24 Hrs. -48 Mesh	Tons 24 Hrs. -65 Mesh	Tons 24 Hrs. -100 Mesh
No. 32...	20	15	12	10	7	4
No. 43...	50	38	30	25	18	11
No. 54...	90	68	52	45	32	18
No. 64½.	300	225	180	150	105	60
No. 75...	655	490	390	325	230	130
No. 86...	1000	750	600	500	360	200

For very hard quartz, these capacities should be reduced one-half; for soft porphyry, like the Nevada Consolidated ores, tonnage could be increased 100%. When the feed is finer than given above, the capacity will be increased somewhat, but not to the extent that one might expect. As an illustration, with medium hard porphyry, as given if the feed is—say ¼-inch with the fines removed, so that 90% is plus 48—if you crush this feed to pass 48 mesh, the capacities given in the above tables will be increased about 10%. The amount of finished product in the feed has much to do with the capacity of the mill. Samples should be sent to our Engineering Department for their examination and advice. Care must be used in estimating tonnages. There is a big difference in capacity whether you crush through 48 or 5% plus 48. Be accurate in discussing screen sizes.

MARCY BALL MILL SIZES

Size No.	Usual Wt. Ball Charge	H.P. to Run	Size Motor* Recommended H. P.	Approx. Shipping Weight, Complete without Balls	Cubical Measurements Packed Ocean Shipment
32	1000	6-8	10	7500	...
43	2500	15-20	20	14500	225
54	5000	30-40	40	24000	260
64½	9000	65-90	100	42000	600
75	18000	100-150	150	75000	650
86	28000	150-225	225	100000	700

*A high starting torque motor is recommended.

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THE METAL SUPPLY COMPANY

2323 EAST 52ND STREET, LOS ANGELES, CALIFORNIA

Smelters and Refiners

XX GRINDING BALLS

Our XX Grinding Balls are made of a superior grade of alloy steel and are guaranteed.

Being made of alloy steel, they possess greater hardness and durability than balls made of cast iron.

To one of our customers, a large mining company in the Southwest, we are indebted for the following information relative to the merits of XX Balls as applied to use in Ball Mills.

Size of Feed	½ inch
Size of Finished Product	All through 48 mesh
Size of Balls Used	4″ and 2″
Ball Charge	34,000 pounds
Ball consumption per ton of ore	2.293 pounds

We are well equipped to supply XX Grinding Balls in any quantities in the following sizes: 2″, 3″, 4″ and 5″.

YOUR INQUIRIES SOLICITED. WRITE FOR FULL INFORMATION.

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MIDWEST FORGE & STEEL CO.

General Offices and Works
21st and Belt Terminal Railroad
P. O. Box No. 430
EAST ST. LOUIS, ILLINOIS, U. S. A.

Products

Hammered Steel Bars, any shape and size.

Hard Steel Grinding and Crushing Balls.

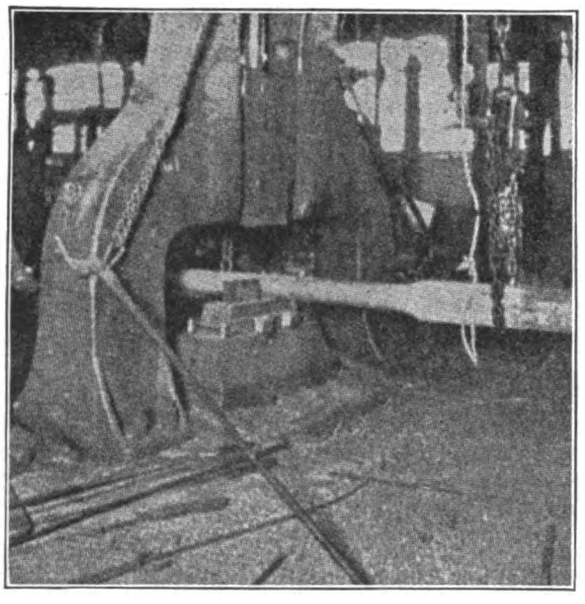
Wilson Shoes and Dies for Stamp Mills.

Forged Steel Liner Plates for Ball and Tube Mills.

Hammered Steel Bars

Made of the best quality "Midwest" Open Hearth Steel Forging Billets.

Made in any shape—round, square, flat or special section.

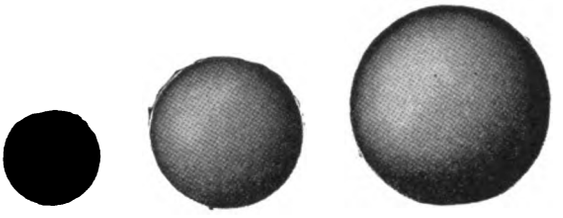


Made in any size—3" to 15" diameter and larger.

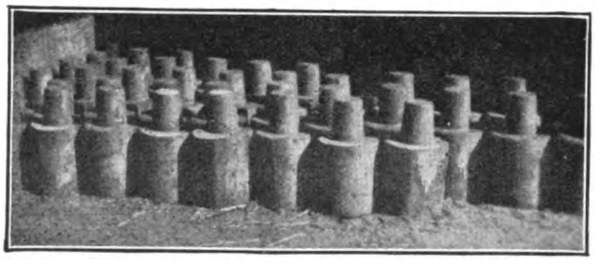
Can be supplied in any quantity—carload lots or less.

Inquiries solicited.

Hard Steel Balls



We are in a position to furnish Hard Steel Balls in diameters of 3", 4" and 5" for use in Grinding and Crushing Machinery.



Wilson Shoes and Dies for Stamp Mills

Are forged from special high-grade Midwest steel, compressed in forms under enormous force, so as to give the greatest possible density, making them equally solid throughout. They are free from blow holes and porous places or soft spots. They never chip off or break.

Forged Steel Liner Plates for Ball and Tube Mills

Your mill is no better than the plates YOU line it with.

SEND US SKETCH OR BLUE PRINT OF LINER PLATES YOU ARE USING.
WE CAN MANUFACTURE PLATES THAT DO NOT BREAK.

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PETTIBONE MULLIKEN CO.

725 Marquette Building, CHICAGO

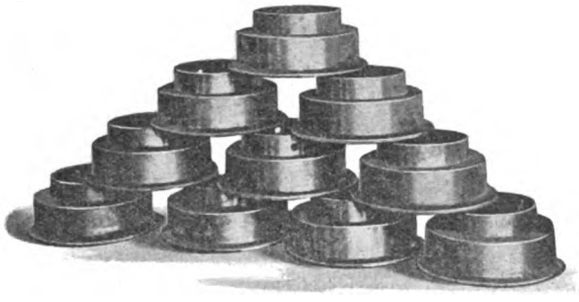
Manufacturers of

Track Equipment for Steam Railways, Mines and Industrial Plants
Manganese Steel Castings

Products

Manganese Steel Castings—Ball, Rod and Tube Mill Liners; Kominuter Plates; Crusher Jaw Plates; Concaves; Heads and Mantles; Chute Plates and Launder Liners; Screen Plates (blank and perforated); Grizzly Bars; Rollers and Sheaves for Wire Cables; Chain and Sprockets; Elevator Buckets; Gears and Pinions; Mine Car Wheels; Crane Wheels; Pulverizer Hammers and Grate Bars; Roll Shells; Mortar Liners; Pins and Bushings; Steam Shovel Parts, etc.

Track Equipment—Frogs; Crossings; Split Switches; Guard Rails; Switch Stands; Taper Rails; Rail Braces; Star Stands; Hub Stands; Transit Switches; Roller Rail Benders; Clamp Frogs.

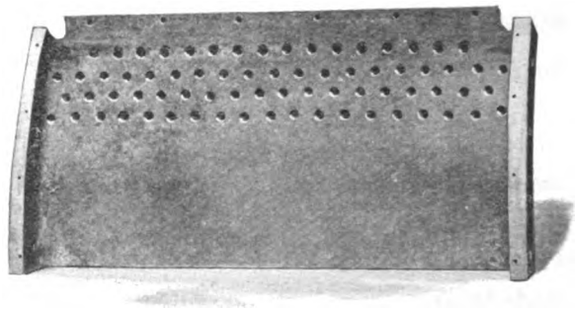


Mine Car Wheels

We produce high grade Manganese Steel Castings of a miscellaneous nature, the quality and workmanship of which is unsurpassed.

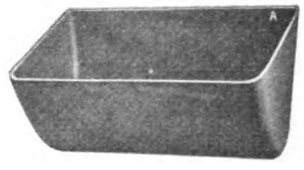
This alloy is made by the electric furnace process, heat treated by the best of modern appliances and carefully inspected before leaving our plant.

Castings either in the rough or accurately machine ground can be furnished at prices which will show economy in their installation.

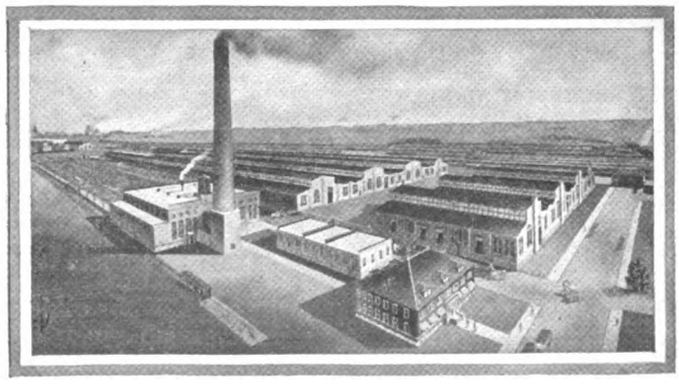


Kominuter Plates

Machinery parts which are subjected to an abrasive action wear rapidly, as a rule, unless made of Manganese Steel. The wear resisting qualities and the high tensile strength of Manganese render it suitable for severe service, such as is encountered in mining work. Break-downs or shut-downs for repairs are minimized in machinery equipped with Manganese Steel.



Elevator Buckets



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SCULLIN STEEL CO.

6700 Manchester Ave., ST. LOUIS, MO.

Forged Heat Treated Steel Balls

Products

Forged Steel Balls; Rods for Rod Mills; Angles; Beams; Billets; Channels; Rounds; Squares; Flats and Deformed Bars.

FORGED STEEL **HEAT TREATED BALLS**

Made of special quality Basic Open Hearth Steel to insure maximum hardness, and heat treated to eliminate brittleness.

Sizes: 1″ to 5″ inclusive.

Table of Weights and Dimensions of Tungssco Steel Balls

Diameter of Ball	Volume, Cubic Inches	Surface, Square Inches	Weight, Pounds Per Ball	Number of Balls Per Net Ton
1 ″	.5236	3.1416	.148	13,500
1¼″	1.0227	4.91	.29	6,900
1½″	1.7671	7.07	.50	4,000
2 ″	4.1888	12.57	1.18	1,695
2½″	8.1813	19.64	2.32	863
3 ″	14.137	28.27	4.0	500
3½″	22.449	38.48	6.35	315
4 ″	33.510	50.26	9.5	211
4½″	47.713	63.62	13.5	148
5 ″	55.45	78.54	18.5	108

We also manufacture RODS for Rod Mills. These rods are rolled from Basic Open Hearth Carbon or Alloy Steel.

The product of our Rolling Mills consists of:

Angles	Billets	Rounds	Flats
Beams	Channels	Squares	Deformed Bars

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COLORADO IRON WORKS CO.

Main Office and Works, DENVER, COLORADO

Branch Office, 30 Church St., NEW YORK

Ore Milling Machinery and Smelting Equipment, Since 1860

Concentration Plants

The design, equipment, and erection of complete concentration plants has long formed a prominent part of our business, and the undivided responsibility thus imposed upon us has placed us in a position to relieve our customers of all doubt as to the successful operation of the mill when completed.

Our line of concentration machinery stands in the very front rank; however, we do not limit the mills we design to equipment of our own manufacture, but embody in our plans the best obtainable whether of our own manufacture or not. Those intending to build concentration plants are invited to correspond with us.

Ore Milling Machinery

Our productions include practically every item required in the equipment of an up-to-date and efficient plant for the recovery of gold, silver, copper, lead or zinc by any of the modern methods of ore treatment. Inquiries are solicited.

Crushers and Crushing Rolls

Our Pamphlet No. 30-A illustrates and describes a full line of jaw crushers and crushing rolls embracing types and sizes suited to practically all requirements.

Rod Mills, Ball Mills and Tube Mills

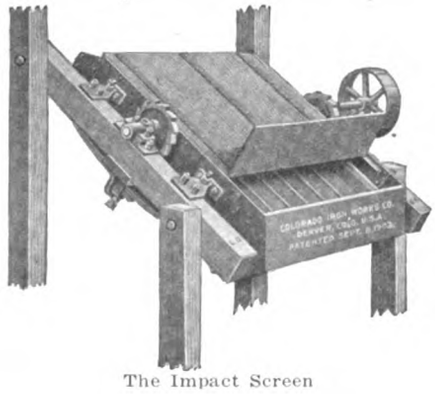
Of superior design and construction embodying many valuable features are shown in Pamphlet No. 31-A.

The Impact Screen

How much that **should** go through a screen actually **does** go through? This is what is meant by screening efficiency, and this is where the Impact Screen shines.

A peculiar jolt is given the ore as it passes over the Impact Screen; a jolt that is characteristic of this screen, and different from all others.

Not a shaking screen in any sense. A dancing movement is imparted to the ore, keeping the meshes of the cloth open, and bringing the coarse to the top and fine to the bottom—just the conditions for efficient work.



The Impact Screen

All mill operators know how concentration is improved by accurate sizing of the pulp. The maximum results are obtainable by use of the Impact Screen, screening either wet or dry.

Ten years' widespread use has emphasized its superiority, although many other screens have been brought out, some imitating its general appearance, others imitating its name.

Thousands in use, mostly in concentration plants, but many in other industries. Send for Pamphlet 9-C. It tells all about the Impact Screen and gives some useful information about the calculation of screening efficiency.

The Akins Classifier

With the Akins Classifier an extremely close separation of the slime is made without the addition of water to the pulp and without supervision on the part of the operator.

The Akins Classifier, Standard Type

In operation the thin pulp entering the feed box meets the slowly moving spiral, the heavier solids settle to the bottom of the trough and are gently advanced out of the surface of the bath toward the sand discharge end, the intermittent spiral permitting the contained moisture to flow back into the charge, the slow turning over of this sand washing the finest solids back and allowing the sand to dry or give up all moisture except that held by capillary attraction. The lighter solids suspended in the liquid flow over the weir into the collecting hopper, to the slime-launder.

The point of separation between sand and slime is controlled by the pitch at which the classifier as a whole is placed and the speed of revolution of the spiral. The inclination is usually about 2½ inches per foot, but may be somewhat more or less depending upon whether the separation is to be made at 60, 80 or 100-mesh or to deliver a slime product containing a maximum of minus 200-mesh solids. An extremely sharp separation can be made when necessary.

SIZES OF THE AKINS CLASSIFIER, STANDARD TYPE

Diameter of Spiral, Inches	Size of Pulley	Speed R.P.M.	Shipping Weight, Lbs.
12	24 x 2	15	250
16	14 x 2	18	310
24	30 x 4½	15	1400
30	30 x 4½	15	2000
36	36 x 4½	15	2600
45	36 x 4½	28	3600
54	48 x 6	30	6400
60	48 x 6	30	9100

An excessive amount of slime in the sand product has a very adverse effect where a classifier works in closed circuit with a ball or tube mill. Here, any slime in the sand only serves to interfere with grinding efficiency and a consideration of the actual amount of slime repeatedly passed through

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the mill as a circulating load should forcefully demonstrate to all the importance of this classifier product. The Akins Classifier is notable for its clean sand product, and mills working in closed circuit with it show correspondingly high capacity.

SIZES OF THE AKINS CLASSIFIER, SUBMERGED TYPE

Diam. of Spiral Inches	Size of Pulley	Speed R.P.M.	Shipping Weight, Lbs.
36	36 x 4½	15	3150
45	36 x 4½	28	4200
54	48 x 8	30	7000

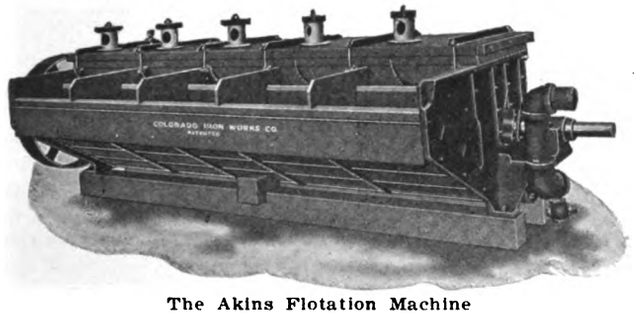
The standard type will make a close separation at 60, 80, or 100-mesh, but where a very clean slime, 90 to 95 per cent. minus 200-mesh, is the prime consideration we supply the Submerged type, which, by greater volume in the bath and increased length of overflow weir gives a finer and cleaner slime, at the same time producing the clean sand product, free from colloidal matter, which the standard type can be depended upon to make.

Pamphlet 24-F gives full details about the Akins Classifier.

The Akins Flotation Machine

The illustration shows the five-cell Akins Flotation and Aeration Machine.

It is built in sizes up to and including eight cells. The machine is designed along entirely novel lines, each cell containing a compartment which is sealed from the atmosphere by the pulp, within which is a rotor partly submerged. The rotor has spiral vanes, each of which as it rotates takes in a definite volume of air as it passes above the pulp level and a definite amount of pulp as it passes through the lower portion of its rotation. The air and pulp mix, and pass through a screen in the central portion of the rotor, below the surface of the pulp, this screen breaking up and further mixing the pulp and air. The air is admitted through a regulating valve in the top of the sealed compartment.



The Akins Flotation Machine

The necessary air is admitted to the cells, independently of each other, under atmospheric pressure; the quantity admitted being under absolute control by the valve on top of each cell.

Important features of the Akins Flotation Machine are its simplicity and the very low power required to operate it, it having been found by careful meter tests that but one-half of one horse power is required per standard cell, and no power for the air, as this is drawn into the machine at atmospheric pressure by the revolving rotor which makes but 60 revolutions per minute.

The machine is capable of extremely close regulation, this being accomplished mainly by control of the air admitted. Pamphlet 33 describes it.

Dewatering Apparatus

Table concentrates are being continuously dewatered in many of the most important plants by the Akins Classifier, and there is nothing better for the purpose.

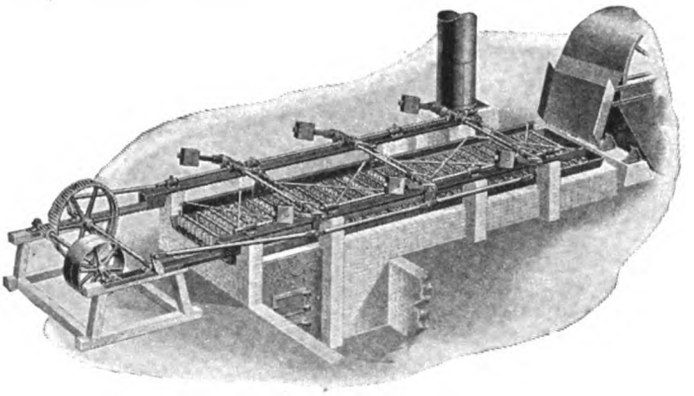
Where flotation concentrates are dealt with, the Portland Filter removes the excess water. (See the Cyanide Section of this catalogue.)

Dewatered flotation concentrates are excessively sticky, making them very expensive to handle. An installation of Portland Filter and Lowden Dryer, so placed that the filter cake falls upon the dryer hearth, does away entirely with all handling of the material while in the sticky condition. Many such plants are in use and they are recognized as being the ideal solution of what was formerly a very vexing problem. Such an installation will pay handsomely in almost every case. Very often the saving in freight alone will return its cost in a short time, but the reduction in cost of storing, loading, unloading, and subsequent treatment frequently is much greater than the saving in cost of transportation.

The Lowden Dryer

The drying of flotation concentrates was a problem for which no satisfactory solution was found prior to the development of the Lowden Dryer, but that this machine completely meets the requirements is evidenced by the repeat orders received from pleased users, and the fact that it has become standard for that work.

It operates in a manner totally unlike any other dryer of the hearth type, and it is just this difference which has made it a complete success where others have failed.



The Lowden Dryer

The Lowden Dryer will handle any of those extremely fine materials which form a sticky mass when wet, without interference by clogging or balling up, and without dust loss.

The saving in dust loss over other machines will on many materials more than cover the whole cost of drying. Send for Pamphlet 32-A.

Manganese and Chrome Steel Castings

We are Selling Agents for the Queen City Manganese and Chrome Steel Castings for wearing parts of crushing and grinding machinery and other severe duty.

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THE DEISTER CONCENTRATOR CO.

FORT WAYNE, IND.

Manufacturers of

Concentrating Tables For Every Purpose

Products

Deister-Overstrom Diagonal-Deck concentrating tables, Nos. 6, 8 and 11, riffled for either sand or slime treatment; No. 7 Diagonal-Deck Coal Washing Table; No. 9 Diagonal-Deck Rougher; No. 10 Diagonal-Deck Iron Ore Tables with decks covered with corrugated rubber and No. 14 Diagonal-Deck Jr. Table, one-third size.

General Data

In the DEISTER-OVERSTROM DIAGONAL DECK type of concentrating table are embodied those principles of deck construction **developed** and **perfected** in the original Deister and Overstrom tables.

Materials and Construction

The **Deister-Overstrom Diagonal-Deck** Tables are comprised of four principal parts, with their necessary accessories: The **deck,** built of best grade of material to be purchased in lumber and linoleum, and reciprocated on self-oiling bearings; the **tilting frame,** built of structural steel; the **main base**—the backbone of the table—built of 9″ steel channels; and, **head motion** of either the Deister or the Overstrom type, both self-oiling.

The primary features of this construction are the **Diagonal-Deck** and the **"pool" riffling.** By a combination of these in the treatment of any ore amenable to wet concentration, is obtained highest efficiency in extraction with a high grade concentrate, small middling and a clean tail.

High Extraction and Clean Tails are obtained: First, by the diagonal disposition, in line of travel naturally taken by the pulp, of the principal concentrating section of the deck which insures the pulp being retained thereon for the longest possible time. Second, ALL RIFFLES ARE PLACED PARALLEL TO THE LINE OF MOTION AND AT AN ANGLE TO THE TAILING DISCHARGE. This serves the advantage of deflected riffles without the whipping action and gives to the stratified mineral particles a free and unobstructed movement toward the concentrate edge of the table.

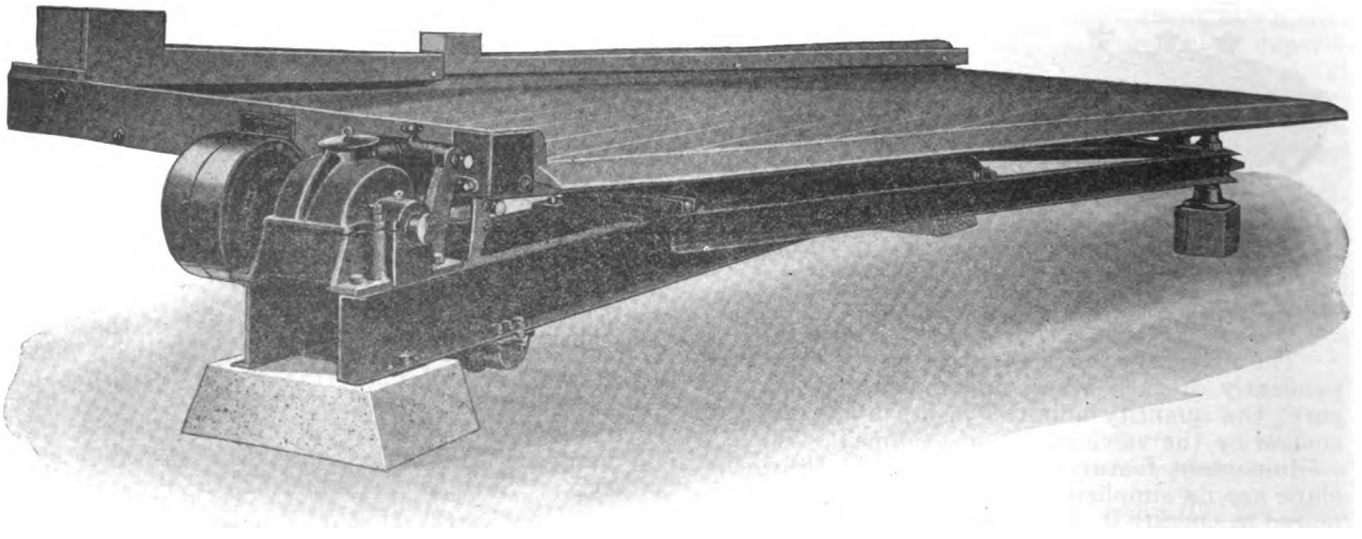
High Grade concentrates are produced by the spreading out in a thin or shallow sheet of the concentrate bed, thus exposing ALL of the fine sand or silica to the action of the dressing water. This "spreading out" feature is of special advantage in the producton of a two or more mineral concentrate (as in the case of a lead-zinc separation) as it reduces to a minimum the middling between two minerals by eliminating the trouble due to overlapping of the two kinds of concentrates.

Small Middling product is maintained by reason of the non-congestion of the concentrates at the middling corner. The spreading out of the concentrates, which thus prevents banking against the sand tails, enables all of the free mineral to come forward without interruption.

Our "Pool" Riffling System, as at first used, is found on the Deister No. 1 and again on the No. 2 sand tables. Its adaptation to the Original, and then to the Improved No. 3 Deister slimer, produced the first reciprocated concentrating table with a higher efficiency in the recovery of the values in very fine slimes than could be obtained by the use of any type of vanner or other slime treating device. The same idea in riffling was applied to the Deister Nos. 4 and 5 sand tables.

Capacities

The capacities of these various tables will depend upon the character of the feed, but will be found to be higher than any other machine manufactured for the same purpose.



Deister-Overstrom Diagonal Deck Table

Write for our catalog. Our fully equipped testing plant is at your service.

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DEISTER MACHINE COMPANY

East Wayne St.. FORT WAYNE, IND., U. S. A.

Manufacturers of

PLAT-O Concentrating Tables and Classifiers

Products

Plat-O Concentrating Tables.

Our older type table, The Simplex, furnished on request.

Deister Cone Baffle Classifier.

Application

Wherever ores or materials are amenable to the wet gravity method of separation, the Plat-O Table is applicable. Plat-O Tables are used in concentrating all metalliferous ores and in washing coal, graphite, etc.

Description

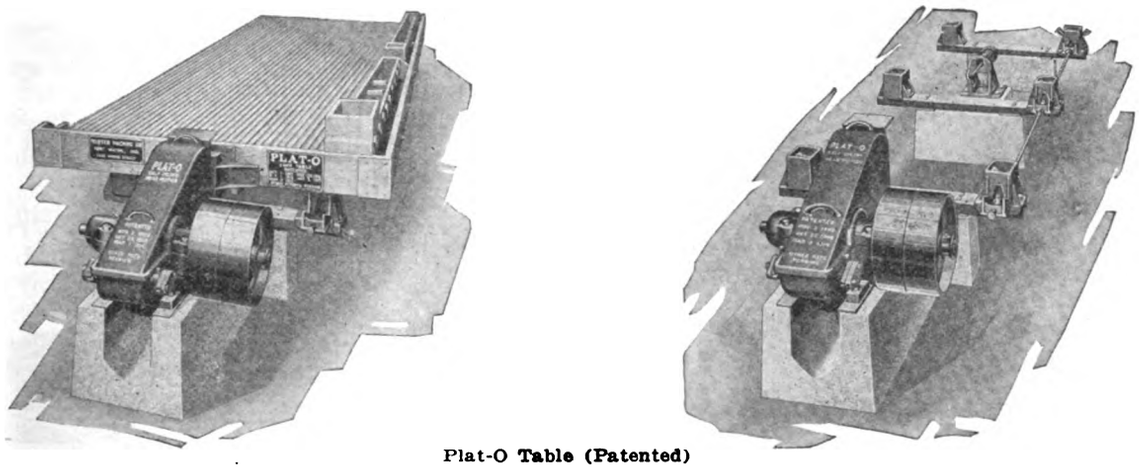
The Plat-O Table is built as ROUGHER, SAND TABLE or SLIME TABLE, and these three types are identically alike except in the riffling of the decks. The positive superiority of the Plat-O Table, both metallurgically and mechanically, over other makes of tables is almost universally known.

THE PATENTED PLATEAU AND RIFFLING SYSTEM and the effective differential of the SELF-OILING HEADMOTION are responsible for the metallurgical superiority. The Plateau is located in the dressing zone of the deck and it consists of this zone being somewhat higher than the general stratifying or concentrating portion of the table deck. Intervening the Plateau and concentrating portion of the deck there is located a so-called resistance plane along a diagonal line. The ends of the riffles are beveled on the underneath side to conform to the slope of the resistance plane. The resistance plane forces a constant line of separation between mineral and gangue or refuse and values, and also makes possible the use of riffles of uniform height throughout their length, thereby INCREASING THE CAPACITY OF THE TABLE. The Patented Riffles are wide, flat strips of wood so spaced as to leave comparatively narrow channels between the main riffles. This displacement feature of riffle allows the feed bed to spread rapidly and uniformly thin, thus allowing stratification to take place more quickly and thoroughly than it does with narrow cleat riffles. THE DIAGONAL DIVISION LINE BETWEEN MINERAL AND GANGUE IS CONSTANT ON THE PLAT-O TABLE. THIS IS NOT TRUE OF OTHER MAKES OF TABLES.

THE SELF-OILING HEADMOTION is scientifically designed and is very strong and rugged. The smooth, differential motion which it imparts to the table deck makes stratification of the feed rapid and positive.

The Mechanical Advantages are the heavy, rugged headmotion which is strictly self-oiling and dust-proof, the large slipper bearings carrying the deck which are also self-oiling and dust-proof, and the unusually simple underconstruction. It is necessary to add oil to the machine only about twice per year.

Tables shipped from our factory are complete, including covers and riffles attached. Linoleum covers and white pine riffles are used on the sand and the slime tables; whereas hardwood riffles are used on the roughing tables, and either linoleum or rubber covers can be furnished.



Plat-O Table (Patented)

Capacities

The capacity of the table is governed by the following: mesh of feed; classified or unclassified feed; if classified, what method used; kind of mineral in ore; percentage of total mineral in feed; and the ratio of concentration desired.

When ordering tables the customer should give as much of this data as possible.

The following list gives the approximate capacity of each type of Plat-O Table, treating either classified or unclassified feed:

Rougher—Feed through 3/16″ screen, 50 to 80 tons per 24 hours.

Sand Table—Feed 20 mesh and finer, 30 to 40 tons per 24 hours.

Slime Table—Feed 60 mesh and finer, 20 to 30 tons per 24 hours.

In some cases our tables are handling much greater loads than those given above, but the figures shown represent the average in each case.

WRITE FOR LITERATURE

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THE ALLEN CONE COMPANY

ENGINEERS

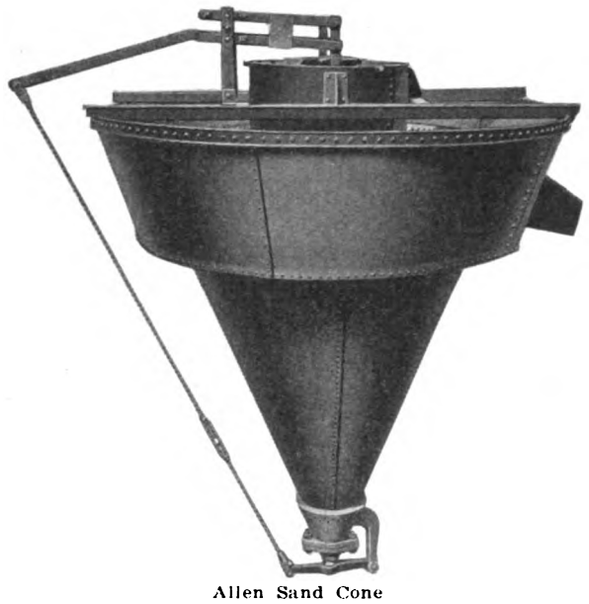
EL PASO, TEXAS

Designers and Builders of

Patented Classifiers, Dewaterers, Thickeners and Sand Washing Tanks

Allen Sand Cone

A Classifier, also used as a dewaterer. Unique as a classifier, in that the Automatic Float Control keeps the sand basin, in which the classification is made, at the same shape and at the same distance from the overflow lip, giving perfect classification, regardless of changes in the solids fed.



Allen Sand Cone

Will classify as coarse as plus and minus 16 mesh, and as fine as plus and minus 200 mesh. Gives a clear overflow when used for **dewatering table concentrates.**

Uses: In closed circuit with ball mill, dewatering table tailings for regrinding, classifying before concentrating tables, building tailings dams, etc. Especially adapted for **closed circuit concentration.** Used with Deflector is **proof against accidental flooding,** which would wash out a ball mill or destroy a tailings dam. May be fitted with Hydraulic Water Device. Bulletin No. 22.

Takes any feed up to 400 gpm. Spigots discharge from 10 to 500 tons standard; special regrinding, 1000 and upward per 24 hours. Standard Sizes: 3'-6", 4'-6", 6'-0", 8'-0", diameter at overflow lip. Special designs for regrinding, for coarse classification and for heavy tonnages.

Allen Sand Tank

A special form of Allen Sand Cone, adapted to heavy water flows and large tonnages of solids. Designed especially for sand washing and allied industries. Used principally as a dewaterer, but also used as a classifier, and has a movable plate, called a Reduction Plate, by which the area is reduced so that coarser sand is thrown into the overflow. Special arrangements permit throwing sand as coarse as ⅛" into the overflow.

Uses: Washing and classifying concrete sand, increasing the modulus of fineness and decreasing the percentage of voids. Loads directly into cars and bins and builds stock piles. May be fitted with Hydraulic Water Device. Bulletin No. 23.

Sizes: 4'-3", 6'-0", 7'-0", and 8'-0", these being the widths of the overflow lips. These will take feeds of 500 gpm., 1000 gpm., 1500 gpm., and 1800 gpm. respectively.

Special Classifier C, for separations up to ¼".

Allen Slime Cone

A thickener which uniformly maintains the density of the thickened discharge. An "actuator" suspended in the lower part rises and falls with changes in the density of the pulp and controls the density of the discharge. May be set for a predetermined density and will keep it constant within a few hundredths of sp. gr. **Automatically clears the spigot of chips, sand and small pieces.** Will thicken sandy pulp.

Uses: General thickening, before filters and for decantation. Thickening flotation concentrates before filtration. In smaller sizes, an excellent classifier before tables in **slime concentration.** Bulletin No. 22.

Sizes: Smallest size 4'-6", other sizes up to 18'-0" diameter at overflow lip. Special designs for larger sizes.

Allen Phosphate Sand Washer
Allen Elevating Sand Washer

These are large hydraulic classifiers, but quite free from the usual defects of this type. In the Phosphate Sand Washer, an "actuator" governs the size of the opening from the main cone to a water chamber, and controls the effect of the classifying current according to the amount of solids fed.

The Allen Elevating Sand Washer is a form with jet elevator discharge. Both types largely used in the Tennessee field for washing the fine sands of phosphate rock. Will make excellent separations on material finer than 200 mesh. Bulletin No. 16.

Made in sizes 8'-0", 10'-0", 12'-0", 14'-0" and 16'-0", diameter at overflow lip.

Hydraulic Water Device

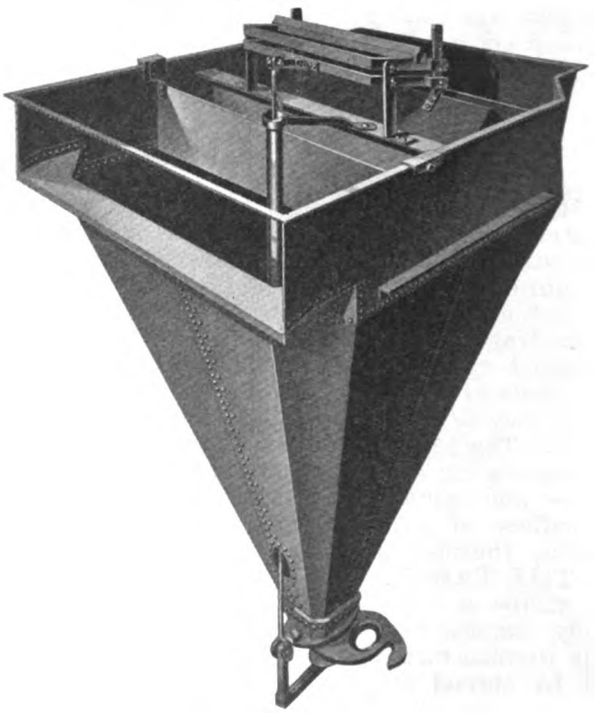
A device by which hydraulic water is introduced into the sand beds of Allen Sand Cones and Sand Tanks. It gives a hindered settling effect, and is very efficient in removing unwanted fines. Sold as an extra.

Deflector

A simple device without moving parts which absolutely prevents damage from accidental flooding by turning any thin, watery discharge into a waste launder.

Information Needed

When writing about Allen Cones or Tanks, be sure to give the water in g.p.m., the tons of solids per hour to be fed, and the classification required.



Allen Sand Tank

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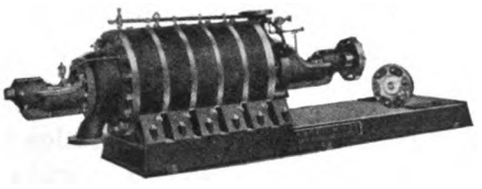
KROGH PUMP AND MACHINERY CO.

147-159 Beale Street,
SAN FRANCISCO, CALIFORNIA

Krogh Solid Lined Tailings Pumps

Krogh Station Pumps

These pumps are of the multi-stage turbine type for high pressure work and are provided with removable diffusion vanes surrounding each runner. Bearings are of ring oiling type with removable bushings. Impeller hubs and recesses are provided with wearing rins. These pumps are



Krogh Station Pumps

provided with the Krogh Patent Hydraulic Automatic balancing device, which eliminates all end thrust under any condition of operation, and this without setting or adjustment of any kind. This device is cast integral with each runner and cannot be placed out of adjustment.

Built in all sizes and for all pressures.

Write for Bulletin 83-A.

Krogh Centrifugal Sinking Pumps

These sinking or unwatering pumps are built in the vertical type for vertical shaft operation or in the incline type for incline operation.

Krogh Centrifugal Sinking Pumps

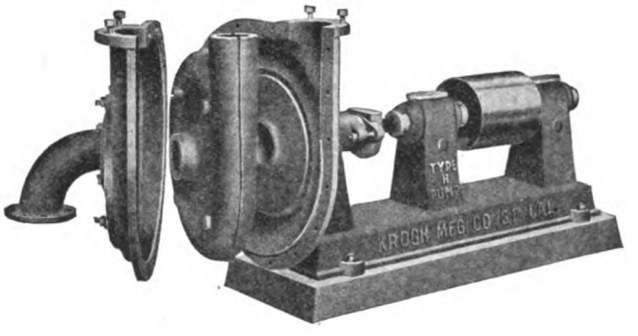
Pumps range in capacities from one hundred gallons per minute upward and for any pumping head desired. All bearings contain removable bushings. Impeller hubs and casing recesses are provided with renewable wearing rings.

These pumps are superior to all other types for unwatering mine shafts or for sinking purposes. Their dimensions and weight for a given capacity are very much less than any other type of pump.

Write for Bulletin 88.

Krogh Solid Lined Tailings Pumps

These pumps are designed to handle water containing tailings, sands, slimes, ashes, etc. They are not intended to handle water containing coarse gravel or other large solids. The liners and impellers are made of chilled car-wheel iron, extremely hard, all finished surfaces being ground to fit, as no steel will machine this metal. This metal is as hard on its face as Manganese steel, but far lower in cost. No through bolts are used in liners. Liners are a machine fit with outer casing and are centered therewith and held to place with set



Krogh Lined Tailings Pump, Belt Drive

screws passing through outer shell. All bearings contain removable bushings, the main bearings being ring oiling.

We carry on hand at all times a complete stock of parts for immediate shipment and furnish a complete price list of these parts.

Nearly two thousand of these pumps have been sold and put in service in mines, mills and factories, and these pumps represent the standard sand pump as recognized by engineers.

TABLE OF SIZES

Size of Pump, Inches	Approximate Weight, Lbs.	Size of Standard Pulley, Inches	Weight Heaviest Single Piece Knocked Down, Lbs.	Capacity Per Minute in Cu. Ft. Water and Solids	List Price	Code Name
2	500	6x6	210	16.5	$450.00	Hetat
3	650	8x8	210	33.0	500.00	Hetma
4	800	8x8	210	53.3	550.00	Hetsol
6	1300	10x10	420	106.5	800.00	Hetorb
8	1800	14x12	500	220.0	1200.00	Hetug

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The Harrington & King Perforating Co.

626 North Union Ave., CHICAGO, ILL., U. S. A.
NEW YORK OFFICE—114 LIBERTY ST.

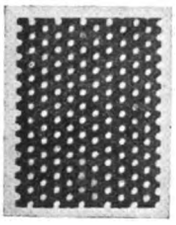
Perforated Metal Sheets

Products

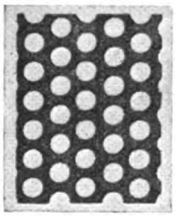
Perforated Sheets and Plates of Steel, Iron, Copper, Brass, Monel, Zinc, Lead, and all other metals.

Purpose

For screening and sizing ore and all minerals; for dewatering, safety guarding, ventilating, etc.

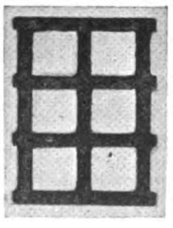


This illustration is of ¾ m/m holes. We furnish as small as .020" in diameter, of which size one square foot contains 90,000 holes.

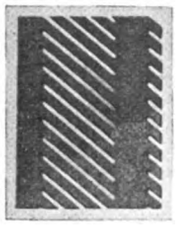


Screens with round perforations effect the most accurate grading of material that is possible. We furnish all sizes in general use and varying by a few thousandths inch in diameter.

Oblong and slot holes have a larger screening capacity than round holes and are desirable for many screening operations.



Square holes are furnished when required, but are not as successfully used for general screening purposes as the rounds and oblongs. There are uses for which they are well adapted.



Diagonal slots are furnished from .010" wide to ⅛" or more. For Stamp Batteries, Huntington and Chilean Mills there is nothing better.

Superior to wire cloth.

Straight and alternate end holes in all widths of opening. Very successfully used for fine screening and in pulverizing mills.

Quality

Is paramount in the making of H. & K. Screens. Material and workmanship are the best obtainable.

Abbreviated Table of Round Perforation With Centers and Thicknesses For Good Screening Results

Round Holes in Inches	Approximate Millimeter Equivalent	Distance Between Centers Inches	Thickness U. S. S. Gauge
1/32	¾	.055	No. 26
1/25	1	.075	No. 24
1/20	1¼	3/32	No. 22
1/18	1⅜	3/32	"
1/16	1½	7/64	No. 18
1/14	1¾	⅛	"
1/12	2	⅛	"
3/32	2½	5/32	Nos. 16 & 14
7/64	2¾	3/16	"
⅛	3	3/16	Nos. 14 & 12
9/64	3½	7/32	"
5/32	4	¼	Nos. 12 & 10
11/64	4¼	¼	"
3/16	4¾	5/16	"
13/64	5	5/16	"
7/32	5½	5/16	"
15/64	6	⅜	"
¼	6¼	⅜	No. 10 & 3/16"
9/32	7	7/16	"
5/16	8	7/16	"
.....	9	9/16	"
⅜	9½	9/16	3/16" & ¼"
7/16	11	21/32	"
½	12¾	¾	"

We furnish innumerable sizes and several centers for each size.

Accuracy in All Details and Excellence of Quality at Lowest Consistent Prices

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HENDRICK MANUFACTURING CO.

General Offices and Works
CARBONDALE, PA.

Branch Offices
NEW YORK PITTSBURGH HAZLETON, PA.

Manufacturers of

Perforated Metal Products

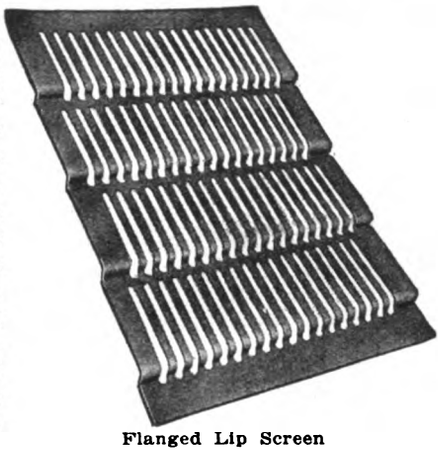
Products

Perforated Metal Screens; Elevator Buckets—Plain and Perforated; Conveyor Trough and Flights; Pans for Apron and Scraper Conveyors; Light and Heavy Steel Plate Construction—Welded Tanks, Hoppers, Coal and Ash Bunkers, Stacks, Breechings, Smoke Flues, Elevator and Conveyor Casings, Steel Truck Bodies, Mine Cars, Mine Car Parts, Pressure Work, Riveted Pipe, Area Gratings; Acetylene Gas and Electric Welding.

Perforated Metal Screens

Made up for individual requirements, for use in the screening and sizing of coal, coke, stone, ore, cement, clay, etc. Round, square and slotted holes. Dies built for special needs.

The PATENT FLANGED LIP SCREEN is manufactured exclusively by us, is specially designed, and is meeting with distinct success in the various fields where it is used. Modern tipples are not complete without this type of screen, and for coke breeze it has no superior. Fully described and illustrated in our Perforated Metal Handbook.



Flanged Lip Screen

ELEVATOR BUCKETS (Plain and Perforated), for the conveying of coal, stone, gravel, clay, ore, etc. We make practically every size, style and description, from the small bucket for sugar to the larger styles for coal and ore handling.

PERFORATED ELEVATOR BUCKETS, for the draining of material while elevating. We handle the entire fabrication in our plant.

CONVEYOR TROUGH AND FLIGHTS, also PANS for Apron and Scraper Conveyors, cut, punched and formed as per your specifications. Our facilities allow us to execute your work in this line in a most satisfactory manner.

LIGHT AND HEAVY STEEL PLATE CONSTRUCTION, such as welded and riveted Tanks, Hoppers, Coal and Ash Bunkers, Stacks, Breechings, Smoke Flues, Elevator and Conveyor Casings, Steel Truck Bodies, Mine Cars, Mine Car Parts, Pressure Work, Riveted Pipe, Area Gratings, Acetylene Gas and Electric Welding.

A large stock of BLANK PLATES and SHEETS from ¾" to No. 24 gauge inclusive permits us to ship promptly the majority of orders, and nearby mills supply special sizes without unreasonable delay.

PERFORATED METAL HANDBOOK WILL BE SENT UPON REQUEST

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NORTMANN-DUFFKE COMPANY

1234 27th Avenue, MILWAUKEE, WIS.

Manufacturers of

Perforated Metal Screens

Products

Perforated Metal Sheets and Plates of Iron, Steel, Brass, Copper, Zinc, Monel, Aluminum, and other metals; Grey Iron Castings.

Perforated Metal Screens

Find ready use in the screening and sizing of material as used in Shaking, Revolving and Chute Screens.

For Washing, where moisture is always present, or for screening material where acids or alkalis are in evidence, we can furnish plates of a material that will give maximum durability consistent with the cost.

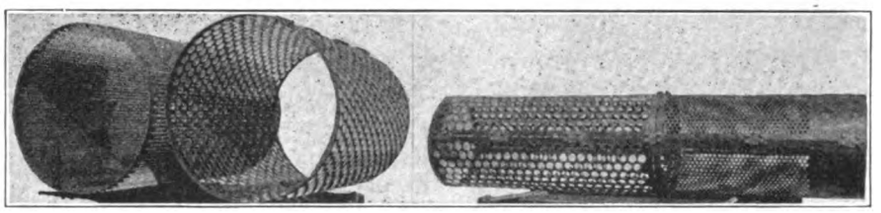
For the lining of revolving screens, we can supply you with screen sections of any desired size, rolled and fastened together with Butt or Lap Joints.

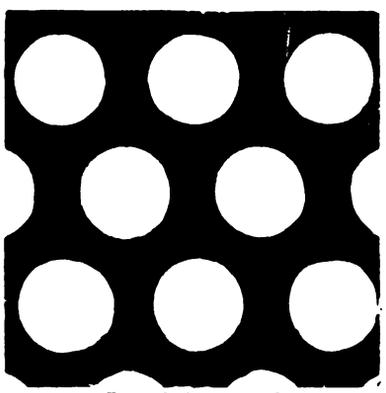
We have over 600 varieties of perforations from which to make selections and the illustrations on this page represent a few of the standard styles of perforations as used in the Mining Industry. If you do not find what you want here, take the matter up with us for suggestions.

Inquiries

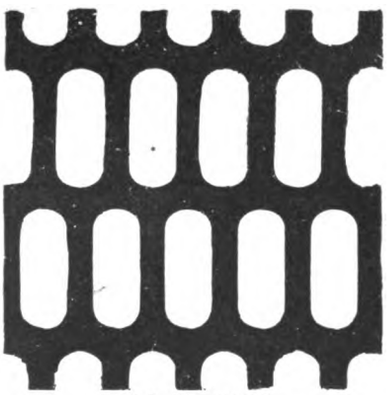
In sending us your inquiries, which will have our prompt attention, kindly state if possible, quantity and size of plates required, thickness of material, size and style of perforations, together with blank margins required and the direction of the flow of material.

You can possibly illustrate the above best on a rough sketch.

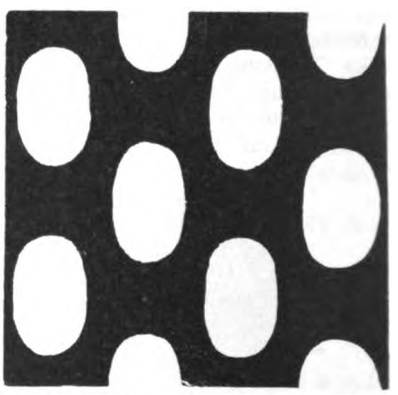




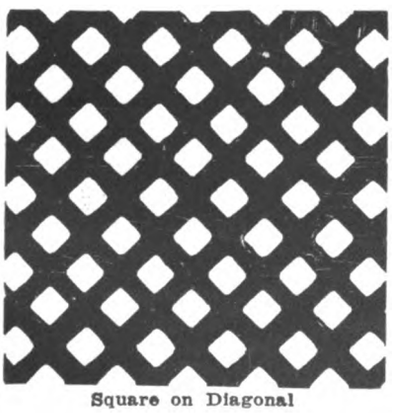
Round Staggered



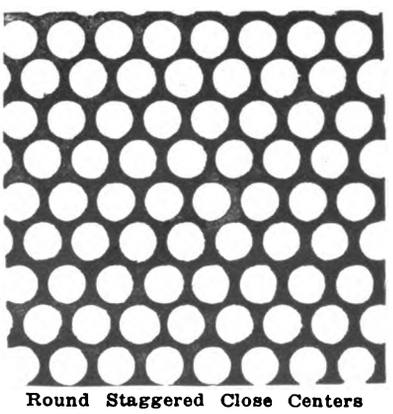
End Staggered



Side Staggered



Square on Diagonal



Round Staggered Close Centers

Side Staggered Slots

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THE LUDLOW-SAYLOR WIRE CO.

ST. LOUIS, MO.

Branch Offices

CHICAGO SALT LAKE CITY EL PASO

Manufacturers of

"The Perfect" Double Crimped Wire Cloth and Rek-Tang Rolled Slot Screens

Products

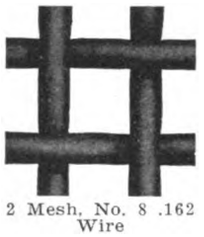
Double Crimped Wire Cloth and REK-TANG Rolled Slot Screens in all commercial metals for all purposes.

We specialize in wire screens for the Mining Industry.

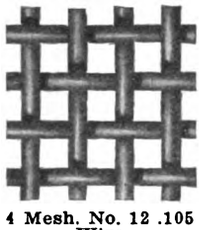
Double Crimped Wire Cloth

Years of experiment and experience have given to Ludlow-Saylor products an unqualified superiority over all other grades of wire cloth.

In the weaving of the "Perfect" Double Crimped Wire Cloth, each wire supports and strengthens every other wire, the shoot wires being arched over and under the warp wires, and the warp wires arched over and under the shoot wires, thus forming a mesh that is absolutely and permanently rigid, eliminating all possibility of wires slipping and insuring an evenness of the screened product. And the wires are not bent but **Crimped,** not with sharp angles, but curved gradually and gracefully over and under the intersecting wires, without any rough corners. Thus the full strength of each wire is retained and its surface kept smooth and unbroken. All strain is equally distributed over the entire screen, and the openings remain uniform and equal as long as there remains enough metal to sustain the weight of the material to be screened.

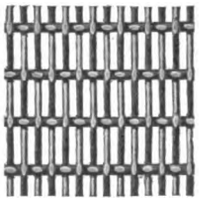


2 Mesh, No. 8 .162 Wire

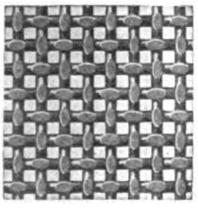


4 Mesh, No. 12 .105 Wire

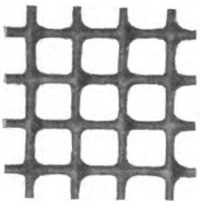
No. 32, Rek-Tang



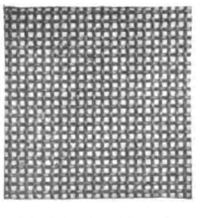
No. 142, Rek-Tang



8 Mesh, No. 16. 063 Wire



4 Mesh, No. 18 .047 Wire

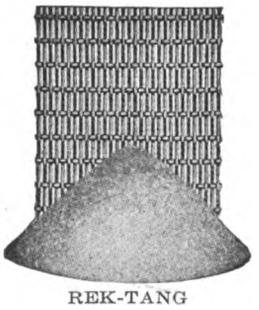


22 Mesh, No. 24 .023 Wire

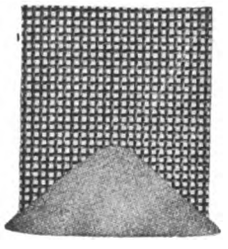
REK-TANG Rolled Slot Screens

A SIGNIFICANT COMPARISON—THE LESSON OF EXPERIENCE.

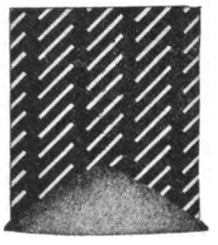
The three illustrations shown below tell a very striking story of the marked superiority in "Producing Power" of REK-TANG ROLLED SLOT SCREENS.



REK-TANG



Square Mesh



Perforated Metal

They show the relative discharging capacity (producing capacity) in a given time of equal areas of (1) REK-TANG, (2) Square Mesh, and (3) Perforated Metal.

They show that the production goes rapidly down hill in the order named, with REK-TANG having a 50% to 100% greater productivity than Perforated Metal.

This comparison is based on actual commercial tests, and proves conclusively the superiority of REK-TANG Screens.

Order Carefully

Be sure and give full information when ordering wire cloth. Don't forget to give: Number of rolls, or number of pieces; length and width of each piece or roll; mesh; decimal size of wire and material from which cloth is to be made.

Delivery

Our central location and tremendous capacity assure the promptest delivery of your orders.

WRITE FOR OUR CATALOG

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NEWARK WIRE CLOTH COMPANY

NEWARK, N. J., U.S.A.

Manufacturers of Wire Cloth

NEWARK

SIGN OF QUALITY

Products

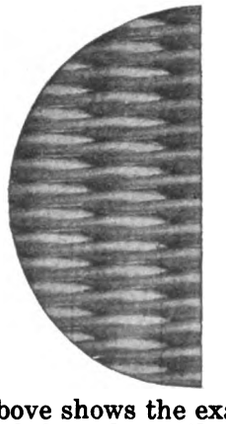
Wire Cloth in all grades, fine and extra fine; Filter Cloths (Metallic); Centrifugal Cloths; Bolting Cloths; Heavy Mining Wire Cloth; Washer Wires; Testing Sieves, U. S. Standard; Chemists' Sieves; Cement Sieves; Foundry Riddles; Coal and Sand Screens.

Wire Cloth may be furnished of the following metals: Brass, Copper, Bronze, Phosphor Bronze, Nickel, Steel, Monel Metal, Silver, Gold and Platinum.

"NEWARK" Metallic Filter Cloth

We are the originators of this grade of metallic filter cloth. We invite close inspection of our several different grades of this material for filtration work and centrifugal linings.

Note the character and even texture of the weave; strength and durability are imparted to the fabric. It has a double surface, is extra strong, and is readily cleaned.



One section above shows the exact size of mesh, while the section below shows the cloth magnified —note the spiral overlap in the weave. "NEWARK" Metallic Filter Cloth is for use in all makes of filter presses in place of cotton, duck, wool, jute or other filtering mediums—and will stand strong solutions which shorten life of others.

Write for Samples.

New U. S. Bureau of Standards Testing Sieve Screen Scale

This screen scale is a departure from any reference to mesh, and is designated by arbitrary numbers.

It is essentially metric. A sieve having an opening of 1-MM is the basic one. The sieves above or below are related to it. The ratio of the width of one opening to the next smaller or larger opening is the fourth root of two.

This scale has been approved by scientific bodies.

Nest of U. S. Standard Testing Sieves

Sieve Number	OPENING		WIRE DIAMETER	
	MM	Inches	MM	Inches
2½	8.00	.315	1.85	.073
3	6.72	.265	1.65	.065
3½	5.66	.223	1.45	.057
4	4.76	.187	1.27	.050
5	4.00	.157	1.12	.044
6	3.36	.132	1.02	.040
7	2.83	.111	.92	.036
8	2.38	.094	.84	.033
10	2.00	.079	.76	.030
12	1.68	.066	.69	.027
14	1.41	.0557	.61	.024
16	1.19	.0468	.54	.021
18	1.00	.0394	.48	.0187
20	.84	.0331	.42	.0165
25	.71	.0278	.37	.0146
30	.59	.0234	.33	.0129
35	.50	.0197	.29	.0113
40	.42	.0166	.25	.0098
45	.35	.0139	.22	.0085
50	.30	.0117	.188	.0074
60	.25	.0098	.162	.0064
70	.21	.0083	.140	.0055
80	.177	.0070	.119	.0047
100	.149	.0059	.102	.0040
120	.125	.0049	.086	.0034
140	.105	.0041	.074	.0029
170	.088	.0035	.063	.0025
200	.074	.0029	.053	.0021
230	.062	.0025	.046	.0018
270	.053	.0021	.041	.0016
325	.044	.0017	.036	.0014

TRY "NEWARK" FOR BETTER WIRE CLOTH—BETTER SERVICE

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B. & W. OIL-LESS CONVEYOR CO.

NOT INC.

2416 Ogden Ave., CHICAGO

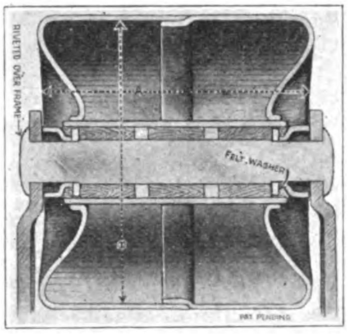
Belt Conveyors and Pulleys

Products

Belt Conveyors, Belting, Gears, Shafting, Sprockets, Pulleys and Screens.

Belt Conveyors

B. & W. Oil-less Pulleys for belt conveyors will run from 8 to 10 years under ordinary conditions. This long service is made possible by their simple construction. The design consists of oil-less bushings, supported by special fibre, the two best wearing surfaces.



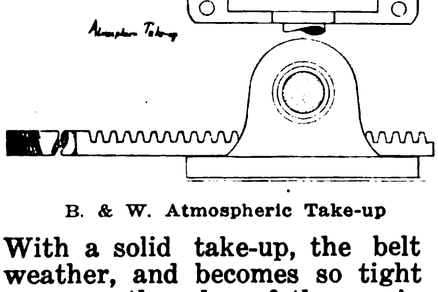
Sectional View of a B. & W. Pulley

This oiling system prevents any dirt or dust coming in contact with the bearings. One of the greatest troubles with ordinary conveyors is the cutting of bearing surfaces caused by sand or grit getting mixed with the grease, when the cap of the grease cup is removed. This is entirely eliminated with the B. & W. system. Although the B. & W. Pulleys are equipped with oil-less bushings, they are packed with high grade grease, which will last as long as the pulley itself.

All B. & W. Pulleys are made of 3/32" cold drawn steel, reinforced at the center to ¼". The hangers are made of ¼" by 3" pressed steel, which are unbreakable and so constructed that they cannot be tampered with. The weight of this equipment is only about two-thirds the weight of the ordinary cast iron equipment, but the tensile strength is twice as great.

Atmospheric Take-up

The B. & W. atmospheric take-up eliminates the side-spilling of material on trough conveyors, caused by shrinkage of the belt in damp weather.


B. & W. Atmospheric Take-up

It has been shown by experiment that a cotton belt in the sun will stretch from 10 to 12 inches for every 50 feet, and a rubber belt from 6 to 8 inches for every 50 feet, when adjusted. With a solid take-up, the belt shrinks in damp weather, and becomes so tight that it starts to sway on the edge of the carrier, spilling the material. The B. & W. take-up always provides the same tension, regardless of the atmospheric condition, thereby eliminating the side guard and twisting of a trough carrier. The B. & W. take-up will remain true, indefinitely, providing the belt does not get too long.

Trough Conveyors

B. & W. Trough Conveyors are made up in two classes—Class A for heavy material and Class B for light material. The Class A Conveyors have from 3 to 8 rollers, according to the width of the belt. The conveyor shown in the illustration, which is for a 30-inch belt, has five 6-inch rollers. All of these trough conveyors use the B. & W. return idler, which is 4¼ inches in diameter. The shafts of the return idlers are stationary, which simplifies the construction, eliminates wear and prevents any fire hazard from overheated bearings. We also have them mounted on board to fit any standard conveyor.

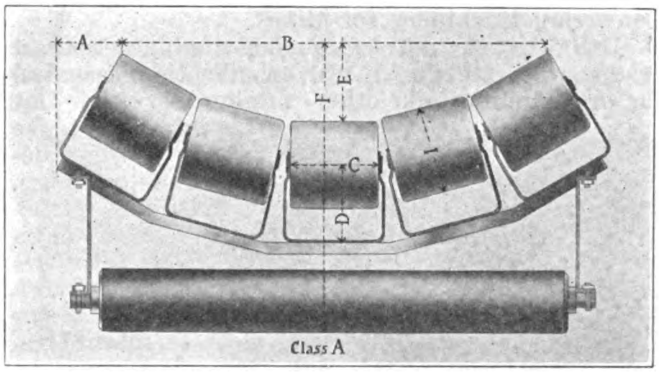

Class A

TABLE NO. 1

Width of Belt, Inches	Dimension—Inches						
	A	B	C	D	E	F	I
18	5	18	6 5/16	5¼	3	17⅝	6
24	5	24½	6 5/16	5¼	3	17⅝	6
30	5	30¼	6 5/16	5¼	5⅛	20½	6
36	5	37	6 5/16	5¼	5⅛	20½	6
40	5	41	6 5/16	5¼	5⅛	23½	6

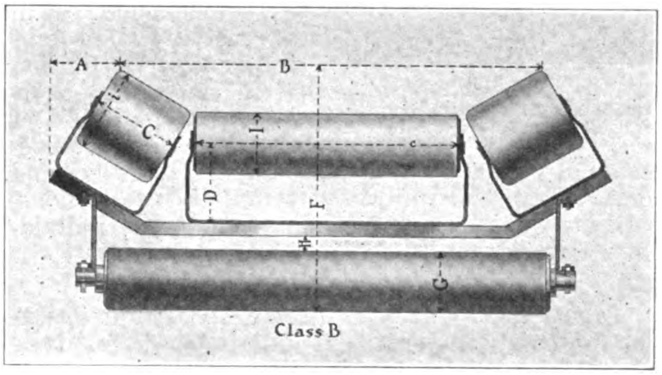

Class B

TABLE NO. 2

Width of Belt, Inches	Dimension—Inches							
	A	B	C	c	D	F	G	I	i
24	5	24½	6 5/16	11¾	5¼	17¼	4¼	4¼	6 5/16
30	5	30¼	6 5/16	17¾	5¼	17¼	4¼	4¼	6 5/16
36	5	37	6 5/16	23¾	5¼	17¼	4¼	4¼	6 5/16
40	5	41	6 5/16	29¾	5¼	17¼	4¼	4¼	6 5/16

A Few Typical Users

The By-Products Co. (Solvay Coke Plant), So. Chicago, Ill.
U. S. Gypsum Co., Chicago, Ill.
Armour & Co. (Grain Elevator), Chicago, Ill.
American Sand & Gravel Co., Chicago, Ill.
Rosenbaum Grain Co. (Irondale Elevator), So. Chicago, Ill.
Reed Sand & Gravel Co., Chicago, Ill.
Brownell Improvement Co., Chicago, Ill.
Chicago Retort and Fire Brick Co., Ottawa, Ill.
Union Limestone Co., Chicago, Ill.
Inland Steel Co., So. Chicago, Ill.
Illinois Steel Co., Joliet, Ill.

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DODGE SALES & ENGINEERING CO.

Distributor of the Products of the

Dodge Manufacturing Corporation

MISHAWAKA, INDIANA

DODGE

BRANCH OFFICES

New York, Pittsburgh, Cincinnati, Chicago, Minneapolis, Houston, San Francisco, Philadelphia, Boston, Newark, Atlanta, St. Louis, Seattle

Dealers in Every Representative City

Elevating and Conveying Machinery

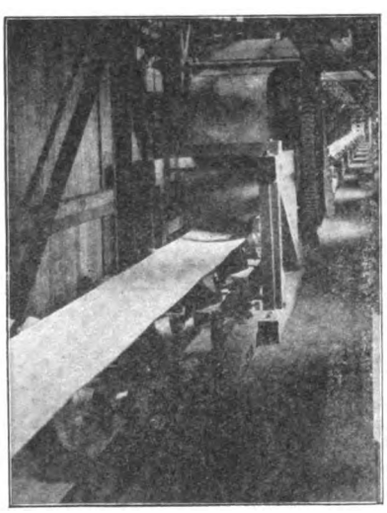
Elevating and Conveying Machinery

Power Transmission Machinery see pages 210, 211 and 212.

For Dodge Heavy Oil Engines see page 178.

Conveying Machinery for Mines

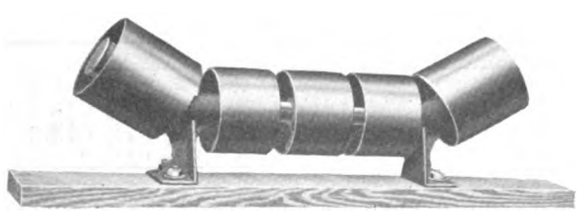
Dodge conveying equipment combines correct design with sturdy, liberal construction essential for ore handling and other mining service. Our standardized line affords prompt decision as to design, layout and structures, saves engineering time, allows prompt delivery and assures the utmost facility of repairs and renewals. A specialized engineering department is maintained at our home office as well as at several of our branch offices. Your material handling requirements will receive the prompt and expert attention of engineers thoroughly familiar with the requirements of your field. We are equipped to design and construct special units and complete installations, giving every possible consideration to the individual requirements of the job.



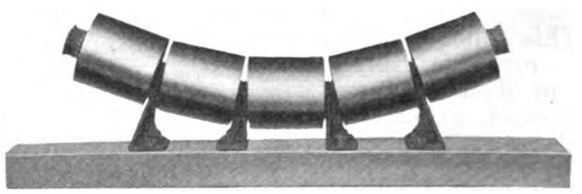
Fixed Tripper Drive Back from Discharge Point; Handling "Chats" in a Missouri Mine

Belt Conveyors

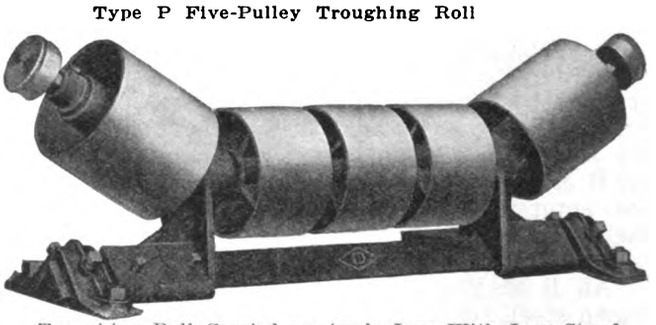
Dodge belt conveyors are in successful operation in many important installations. This type of conveyor is especially adapted for service where large quantities of material must be handled quickly and economically. Dodge conveyor rolls are furnished in two general types, troughed and flat. Our complete line includes all types adapted for use in the mining field.



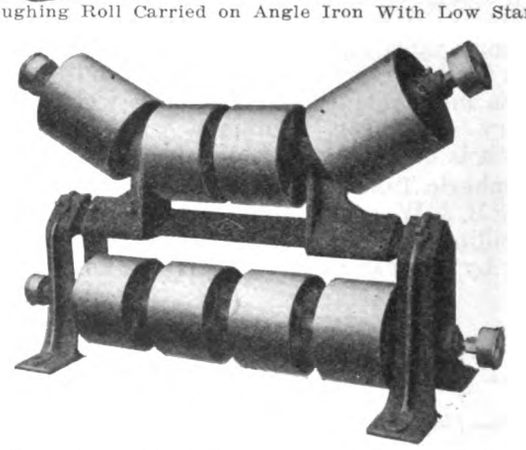
Type I Troughing Roll Mounted on Plank



Type P Five-Pulley Troughing Roll



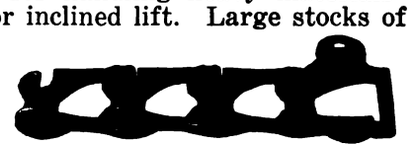
Troughing Roll Carried on Angle Iron With Low Stand



Type A Combined Troughing and Return Rolls

Elevators

We design and manufacture continuous bucket elevators for handling heavy materials on either vertical or inclined lift. Large stocks of standard size elevator buckets and chain are carried at our warehouses convenient to the mining field. Thus situations permitting the use of standardized



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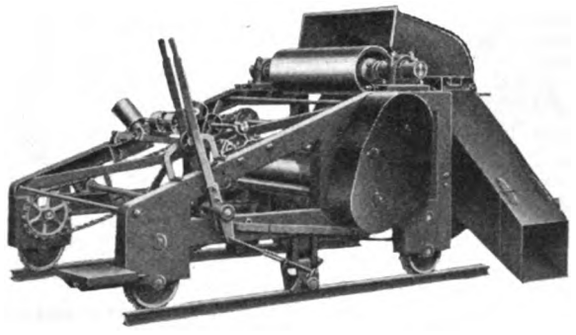
equipment can be promptly and satisfactorily met. Special equipment can be efficiently handled by our engineering department either at our home office or at the offices convenient to your opreations.

Trippers

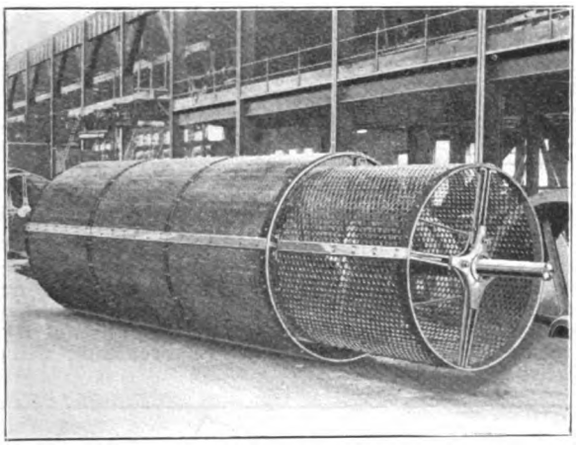
Either stationary or travelling. The Type S tripper shown in illustration is extensively used in ore reduction plants and for service of a similar nature. It is self-propelled through friction gear-



ing in casing outside the frame, to the wheels through chain and gears inside the frame. Can be equipped for manual or automatic operation. We also make steel frame travelling trippers for unusually heavy service under severe conditions.

Feeders

Continuous processes require even flow of materials. Feeders are used to give greater capacity of conveyors and elevators as well as more satisfactory results by assuring a controlled uniform feed. We are equipped to design and construct feeders to successfully handle any mining service.



Screens

We manufacture all kinds of screens for all mining purposes.

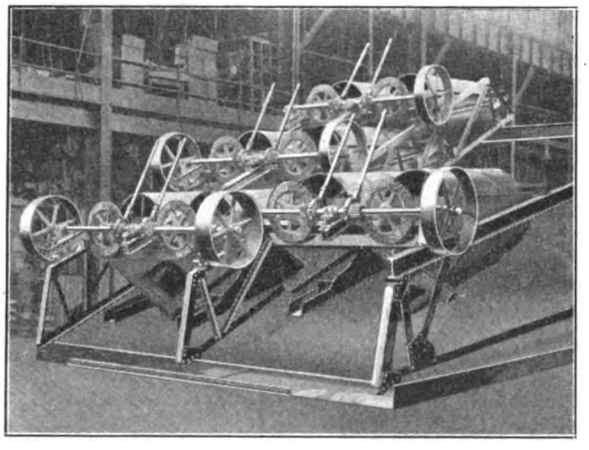
Conveyor Spur Gears

There is a manifest advantage in being able to obtain gearing promptly from stock. It will be found that the average user can accommodate his requirements in most cases from a reasonable number of sizes in general use. By boring and keyseating each gear for a shaft that will transmit the full power of the gear, we make it possible for the operator or engineers to make selections

quickly and with assurance of reasonable delivery and good service.

Trommels

We are prepared to construct trommels or ore graders in accordance with specifications furnished



or to design and manufacture equipment of this kind to meet the needs of any service.

Sprockets

We carry a large stock of sprocket patterns selected on a basis of average requirements at our

factory from which it is possible to furnish finished sprockets promptly on order.

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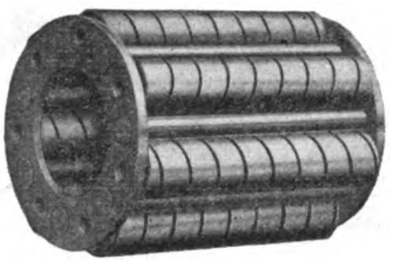
HYATT ROLLER BEARING COMPANY

NEW YORK, N. Y.

Hyatt Roller Bearings for Conveyors

General Advantages

When applied to the drive mechanisms and idler pulleys of belt conveyors Hyatt roller bearings impart their true rolling motion, eliminating 50 to 75% of the friction; because of their grease-tight housings they only require lubrication three or four times a year and because of their durability they operate for years without adjustment or replacement.



The friction elimination reduces the power required to operate. It allows the use of lighter, less expensive belts, which last longer on the freely turning idlers; longer single span belts; lighter driving motors; lighter electrical equipment. All this results in real economies, due to lower first cost, lower operating costs (power, lubricant, labor), and lower maintenance costs (belt and idler replacement).

Power Saving

To determine just how much power the use of Hyatt bearings on conveyors will save, we have, with the co-operation of the operating executives of many large plants where Hyatt equipped conveyors are in operation, conducted thorough tests on both plain bearing and Hyatt bearing conveyors.

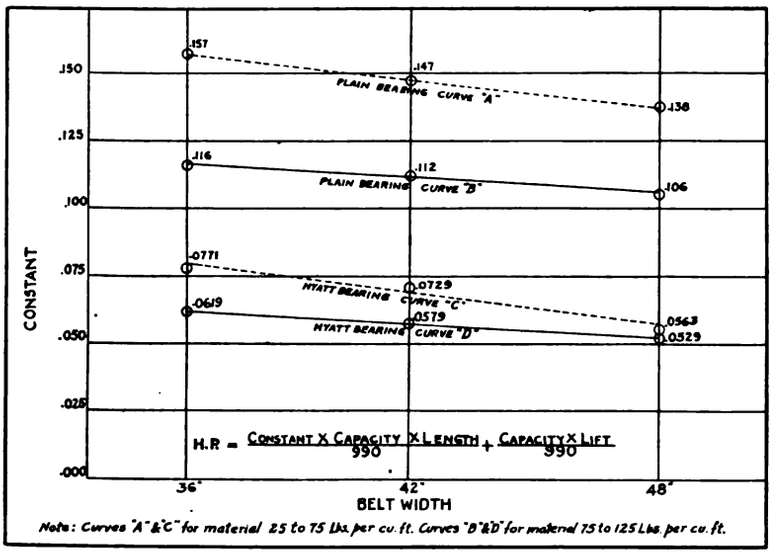
To clearly understand the important results of these tests, it is necessary to consider the standard belt conveyor power formula which is given on the chart on this page.

The second part of this formula represents the work done against gravity and is applicable to any conveyor that is inclined.

The other part of the formula represents the horse power consumed by friction in the idler pulleys and driving mechanism when the belt is loaded.

For conveyors of equal capacity and length, therefore, the Constant would be proportional to the friction in the idlers and drive mechanism.

The solid line curves, "B" and "D" on the chart, are the plain bearing and Hyatt bearing constants respectively for conveyors handling material weighing from 75 to 125 pounds per cubic foot as determined by these tests. These constants are to be used for heavy material such as ores, limestone, etc. The dotted line curves "A" and "C" are the plain bearing and Hyatt bearing constant respectively, for materials such as coal and coke, weighing from 25 to 75 pounds per cubic foot.



Determining the Power to Operate Conveyors

To determine the power necessary to operate any conveyor if it is equipped with Hyatt roller bearings, it is necessary only to determine from the chart the value of the Hyatt constant for that width of conveyor and for the weight of material to be conveyed, substitute this value and the other necessary data relative to the conveyor in the formula, and solve for the horse power.

Location of Hyatt Bearing Conveyors

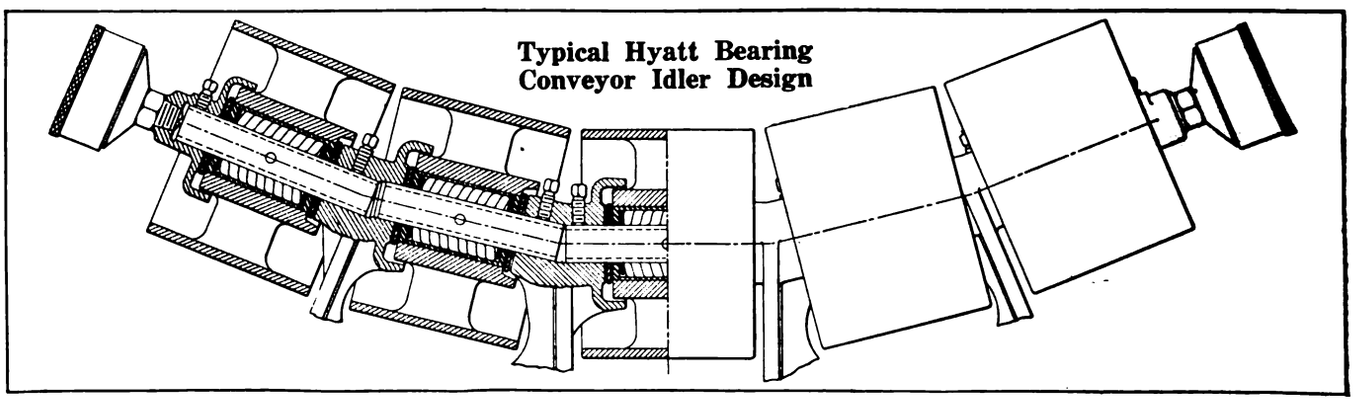
The folloing metal mining companies, quarries and allied industries have from one to twenty-four Hyatt equipped conveyors in operation.

- United Verde Copper Mining Company
- Braden Copper Mining Company
- Berkshire Mining & Development Company
- Chile Exploration Co.
- Utah Copper Company
- Jas. A. Hill Mining Co.
- G. W. Johnson Limestone Company
- Michigan Limestone & Chemical Company
- Pittsburgh Limestone Company
- Templeton Limestone Company
- Tennessee Copper Co.
- Texas Gulf Sulphur Co.
- Cleveland-Canton Coal Company
- Donner Union Coke Co.
- Fall River Gas Coke Co.
- Grasselli Chemical Co.
- Hartman Blanchard Co.
- Pittsburgh Crucible Steel Company
- United States Coal & Coke Company
- Whitaker-Glessner Co.
- Ashtabula Sand & Gravel Company

There are many Hyatt equipped conveyors in other industries also, giving the same dependable, economical service.

How to Get Hyatt Bearing Conveyors

All conveyor manufacturers furnish or will furnish their conveyors equipped with Hyatt roller bearings in the drive mechanisms and idlers. Our conveyor engineers will assist you and your conveyor manufacturer in the design of Hyatt equipped conveyors to meet your requirements, without obligation.



Typical Hyatt Bearing Conveyor Idler Design

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LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

Branch Offices and Agencies

New York.....Woolworth Building
Boston.....49 Federal Street
Pittsburgh.....1501 Park Bldg.
St. Louis...Central National Bank Bldg.
Buffalo.....547 Ellicott Square
Wilkes-Barre..2nd National Bank Bldg.
Cleveland.....429 Kirby Bldg.
Huntington, W.Va., Robson-Prichard Bldg.
Detroit.....4210 Woodward Ave.
Kansas City, Mo....306 Elmhurst Bldg.
Seattle.....820 First Ave., S.
Portland, Ore.....161 First St.
San Francisco.....168 Second St.
Los Angeles.....163 N. Los Angeles St.
Denver....Lindrooth, Shubart & Co., Boston Bldg.
Louisville, Ky.....Frederick Wehle, Starks Bldg.
New Orleans.....C. O. Hinz, 504 Carondelet Bldg.
Birmingham, Ala.....S. L. Morrow, 720 Brown-Marx Bldg.

Canadian Link-Belt Co., Ltd., Toronto and Montreal
H. W. Caldwell & Son Co., Chicago, New York, Dallas, Texas

Manufacturers of

Elevating, Conveying and Power Transmission Machinery and Accessories

For Description of Other Products See Pages 208 and 499

Products for Mines and Quarries

Belt, Bucket, Apron and Pan Conveyors; Bucket Elevators; Locomotive Cranes; Crawler Cranes; Wagon and Truck Portable Loaders; Electric Hoists; Sand and Gravel Washing Equipment; Screens; Crushers; Chains; Wheels; Gears; Buckets; Friction Clutches; Transmission Machinery; Silent Chain Drives; Roller Chain Drives, etc.

5-Roll >MULTIROLL< Idler

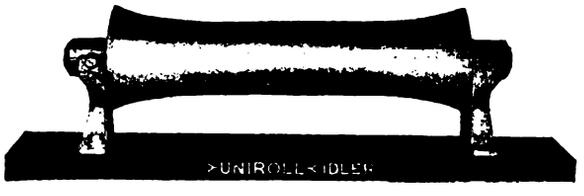
Belt Conveyors

The Link-Belt Company is the recognized pioneer in the art of conveying materials, and our various elevating and conveying devices today represent the highest development of their respective types. We manufacture extensively Link-Belt or chain conveyors, carriers, screw conveyors, belt conveyors, and all other approved designs of conveyors and elevators; and, without prejudice, employ each where it serves best.

The belt conveyor is one of the oldest known conveying devices, and has a wide field of usefulness. It is practicable to run these conveyors at relatively high speeds, which adapts them well for large capacities, and particularly for conveying long distances.

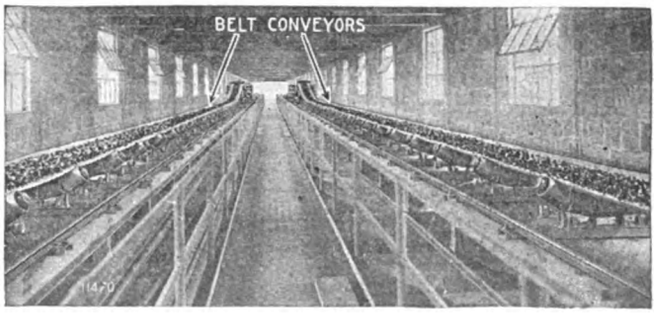
The Link-Belt >UNIROLL< idler has a single roll with flared (cast) ends, secured to a shaft carried in stationary bearings. It combines the simplicity of the plain straight roll with the increased carrying capacity of a troughed idler, the ends being sufficiently flared to check effectually the flowing of the material carried. It presents to the belt a smooth unbroken surface that cannot cause creases, or crack the belt. The differential action between the bell ends and the belt is slight and results in no noticeable depreciation of the belt—in fact, no greater slip than appearance shows incident to other types of idlers.

The >UNIROLL< idlers are carried in stationary self-aligning bearings,—roller or chain-oiling. Roller bearings furnish the maximum attainable efficiency, and oil, for relatively light loads at high speed, is superior to grease, which is uncertain, and at low temperature often acts as a drag. The bearings require attention only at intervals of several months, and the rolls rarely fail to revolve even if this be neglected. The very costly labor for daily attendance and inspection is thus eliminated.



The >MULTIROLL< Troughing Idler, by reason of the deepest troughing of the belt consistent with good practice, gives the maximum carrying capacity for a given width of belt, and is very extensively used, being especially well adapted for handling coarsely-broken material, and particularly at inclinations. For the narrower belts three rolls in line are used, and five for the wider belts, thus permitting the belt to assume an approximately uniform curve, without sharp bends.

The individual brackets in this idler are cast integral, and afterwards split, for receiving the rolls. This assures ease of assembly and perfect alignment. Each roll is of cast-iron, accurately ground, and carried on a hollow shaft, lubrication being supplied through the shaft by compression grease cups or forced feed, as preferred.



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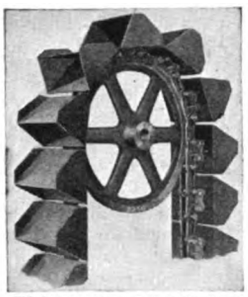
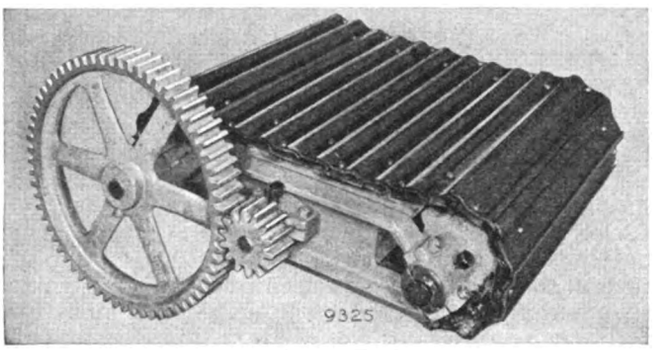
Elevators



This type of bucket elevator permits direct feeding of material. The flanged front of each bucket forms a chute for the discharge from the succeeding bucket, thus effecting a clean discharge at slow speed.

An elevator composed of malleable iron buckets, >FLINT-RIM< sprocket wheel and "C" Class (combination iron and steel) chain.



Apron Feeder

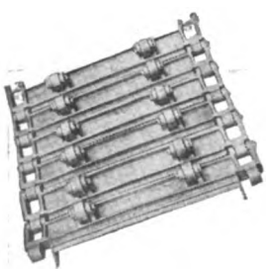
Feeders

Best results in the operation of elevators and conveyors can be realized only when the materials are delivered to them uniformly and properly. There is no economy in the alternate intervals of overloading and underloading, unavoidable when no definite methods of regular feeding are used.

The type of apron feeder illustrated is adapted to the handling of heavy lump material, and has large carrying capacities. It is used very extensively in mills and smelters for the handling of ore. Its construction is heavy and rugged, which is necessary as the ore in the bin rests directly upon the feeder. It requires relatively little head room, considering its capacity, is proportioned accurately, and is easily regulated.

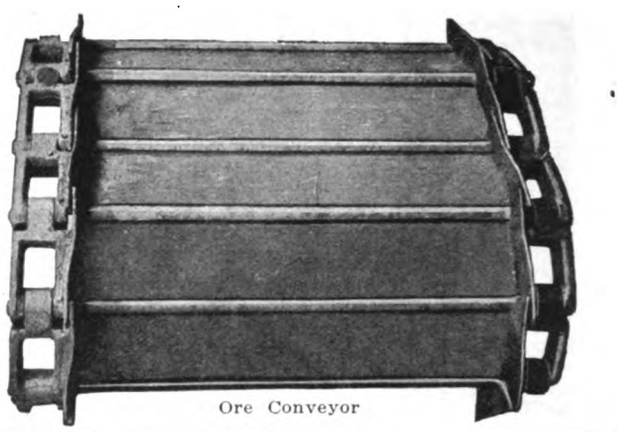
This feeder may be made of any length or width to meet requirements, with capacities as high as 200 tons per hour, and to handle up to 18-inch lump ore.

Conveyors for Ore

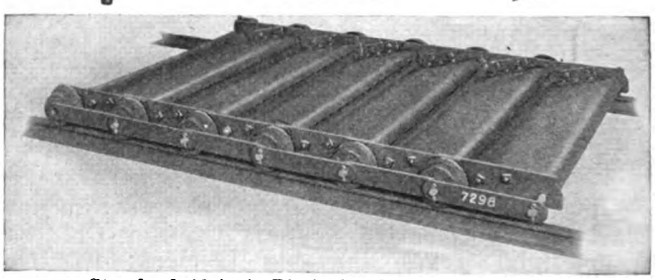


These apron conveyors are designed especially as feeders and carriers for the heaviest ore. The chains and pans are cast integral, of high carbon steel, heat-treated, with no bolts or rivets to become loosened by impact of heavy material. This design gives the great strength, stiffness and durability that is essential.

We are prepared to design and build special types of iron or steel pan conveyors to handle any kind of material. Estimates submitted on receipt of full particulars.



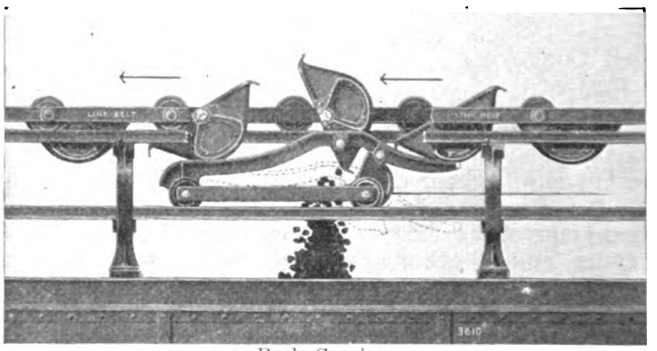
Ore Conveyor



Standard 12-inch Pitch Steel Apron Conveyor

The Peck Carrier

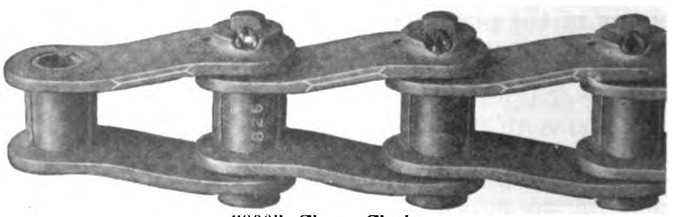
The Peck Overlapping Pivoted Bucket Carrier, Patented, is the highest development of this type of conveyor—in its inherent design, details of construction and accuracy of workmanship. It is the recognized standard machine for handling coal and ashes in modern power houses, as well as cement, clinker, stone, ore and other abrasive materials. Send for book No. 220.



Peck Carrier

Chains

From the Original Ewart Detachable Link-Belt for simple elevators and conveyors and power transmission to the highly efficient Link-Belt Silent Chain for high speed power transmission in large or small units, there are types of Link-Belt chains to meet the requirements of every service in elevating, conveying and power transmission.



"800" Class Chain

"800" Class Chain illustrated is used for elevating and conveying gritty materials, and for the

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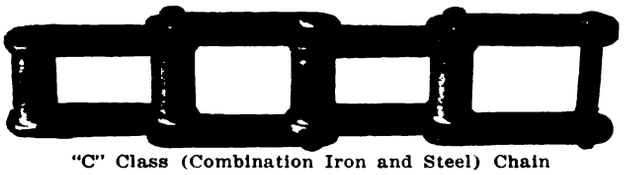


"C" Class (Combination Iron and Steel) Chain

transmission of power. In this chain, both the joint-wear and the wear that results from engagement with the sprocket wheel, are taken care of by hard, renewable steel pins and bushings. Both pins and bushings have long been made of thoroughly case-hardened steel, to secure durability. The pins have T-heads which fit closely between lugs on the side bars, while the opposite ends are flattened to fit snugly in corresponding recesses, thus preventing any tendency to rock, work loose, and start wear at these points, even under heavy strains. The pins are regularly furnished in the detachable type.

"C" Class Chain is an inexpensive type for elevators and conveyors where the practical requirements are strength and low cost.

>FLINT-RIM< Sprocket Wheels

These wheels are made by a special process. They give a hard, smooth bearing surface, free from sand. This surface, extends to a depth of ¼ inch to ½ inch and prolongs the life of the wheel far beyond that of ordinary cast iron. There is no better combination than Link-Belt >FLINT-RIM< Wheels and Link-Belt Chains.

Gears

Link-Belt Gears are machine molded, which makes them more uniform, and better proportioned. The teeth are molded from a single tooth pattern, the spacing being done by accurate machinery. A machine molded gear is as near perfect as a cast-iron gear can be made. We make gears of all types—spur, bevel, miter, worm and worm wheels, cast iron, semi-steel, teeth machine molded or machine cut.

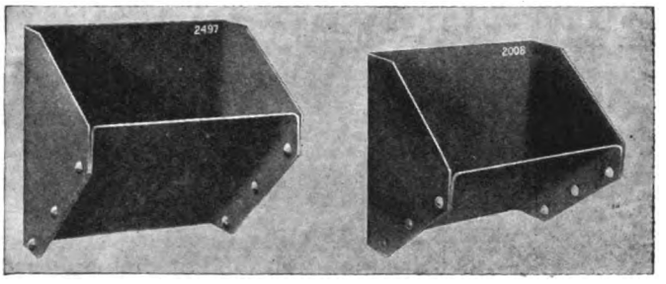
Helicoid Conveyor

The perfect spiral or screw conveyor. The continuous flight is rolled from a single strip of metal, and the flight, even before the pipe is inserted, is very strong and resists to the full strength of the metal the lateral pressure due to pushing forward the material.

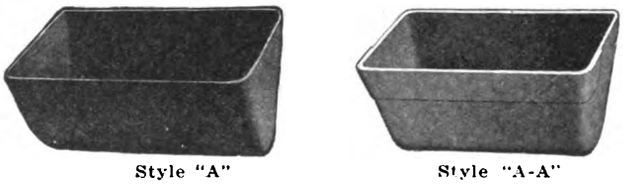
While we furnish both Helicoid Conveyor and conveyor of the old style sectional flight type, we always recommend Helicoid Conveyor.

Buckets

Overlapping continuous buckets are used where it is necessary to prevent fine material passing back between the buckets. In some classes of work it is desirable to use curved inside bottoms, but the ordinary V-shaped bottom is less expensive and often answers the purpose just as well. We furnish either as required. The flanged front of each bucket forms a chute for the discharge from the succeeding bucket, thus effecting a clear discharge at slow speed. It also permits feeding the material directly into the buckets, thus avoiding the wear and strain of digging through an accumulation of material in an elevator boot.



Ordinary V-Shaped-Bottom Buckets



Style "A" Style "A-A"

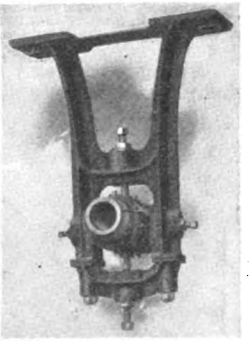
Malleable Iron Buckets

Malleable Iron Buckets

Our stock of malleable iron buckets is complete in every sense, placing us in a position to make immediate shipment of practically any standard size or type. The material entering these buckets is of the same high standard as that used in malleable Link-Belt, for which we are known the world over. They are seamless, strong and smooth, and are designed to insure proper filling in the boot, and free and clean delivery at the head.

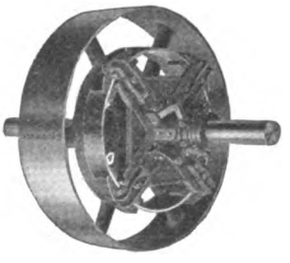
They have reinforced corners, which make them stronger than steel buckets of equal gauge, and the material of which they are made resists wear much better than the soft grade of steel which has to be used in the manufacture of steel buckets.

Buckets are furnished punched or plain. In ordering, state whether buckets are to be punched for flat belt or Link-Belt, and if for the latter, give size and number of strand of Link-Belt and style of attachment.



Transmission Machinery

The Link-Belt line is complete. Bearings—heavy, properly designed, and well finished. Pulleys of ample weight and accurately turned. The entire line has achieved outstanding recognition under hard service. The Link-Belt line includes bearings, pulleys, friction clutches,



hangers, floor stands, sheaves, band wheels, fly wheels, sprocket wheels, etc.

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THE JEFFREY MANUFACTURING COMPANY

959 North Fourth Street, COLUMBUS, OHIO

TYPE WIRE OFFICES

New York City, Room 2008, 30 Church St. Phone Cortlandt 5417 or Cortlandt 7241 — Pittsburgh, Pa., 2111 Farmers Bank Bldg. Phone Grant 407 — Chicago, Ill., 858 McCormick Bldg. Phone Harrison 8008

Telephone any of the type-wire offices mentioned above, and your request for Jeffrey Products or Service will be at once typed over our own private wire to Columbus, and the information given you quickly and without extra cost

Products For Metal Mines, Mills, Smelters, Quarries, Etc.

Conveyors—Belt, Pan, Apron, Portable, Retarding, Scraper, Screw, Spiral; Elevators—Belt, Bucket; Coal and Ash Handling Equipments; Weigh Hoppers and Baskets; Conveyor Belts and Trippers; Buckets—Elevating and Conveying, Ore, etc.; Chain—Conveyor, Rivetless, Roller; Chain Drives; Feeders—Apron, Conveyor, Ore, Reciprocating.

Steel Thimble Roller Chains for Heavy Elevator or Apron Conveyor Service

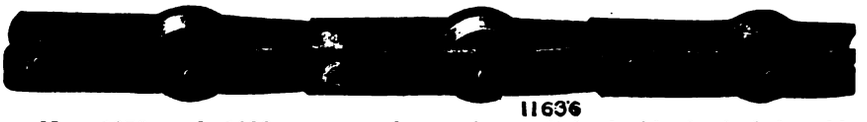
DIMENSIONS STEEL THIMBLE ROLLER CHAINS

Chain Number	Pitch, Inches	Approx. Weight, lbs. per ft.	Working Strength at 150 ft. per min. lbs.	Max. Speed, ft. per min.	Worksop Sprocket Number
180	12.0	14.20	6500	200	180
182½	18.0	18.60	9700	150	182
276	12.0	12.20	5200	300	180
987	24.0	19	12000	100	987
1018	18.0	18.3	8750	165	1018
1072	30.0	20.0	15000	100	1072
1074	24.0	22.0	15000	100	987
1076	30.00	30.0	25000	100	1076
1086	24.0	38.0	25000	100	1086
1092	18.0	31.0	15600	100	1092
1093	24.0	27.0	15600	100	987

Chains in bold face type are carried in stock.

11637

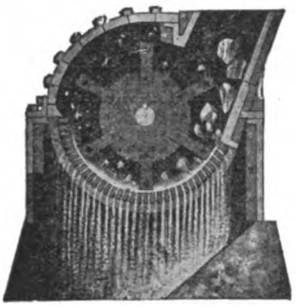
Nos. 987, 1018, 1072 and 1074 are double bushed chains with white iron rollers, made especially for Pivoted Bucket Carriers and similar service where the use of cross rods is essential.



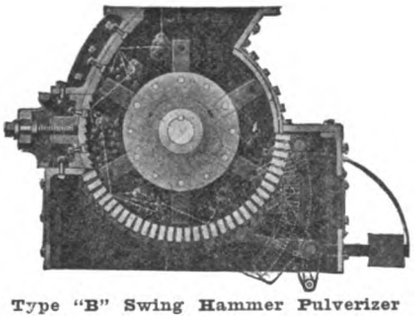
11636

Nos. 1076 and 1086 are very heavy long pitch double bushed knuckle chains. The rollers have hardened renewable bushings, strong and well fitted for heavy stone Elevator service.

Nos. 276, 180, 182½, 1092 and 1093 are long pitch chains and with angle iron detachments are especially adapted for apron conveyors and continuous Bucket Elevators of large capacity.

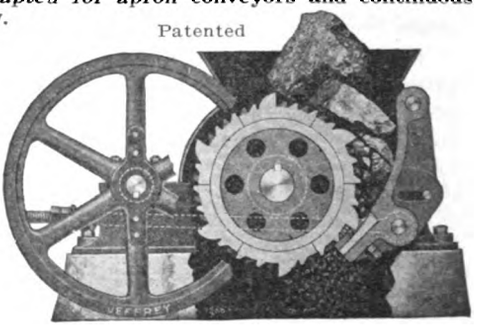


Type "A" Swing Hammer Pulverizer



Type "B" Swing Hammer Pulverizer

Patented



Jeffrey Single Roll Crusher

Swing Hammer Pulverizers for reducing Limestone, Coal, Lime, Gypsum, Marl, Shale and many other products. Catalog No. 368-D.

Single and Double Roll Crushers for reducing Coal, Coke. Catalog No. 359-I.

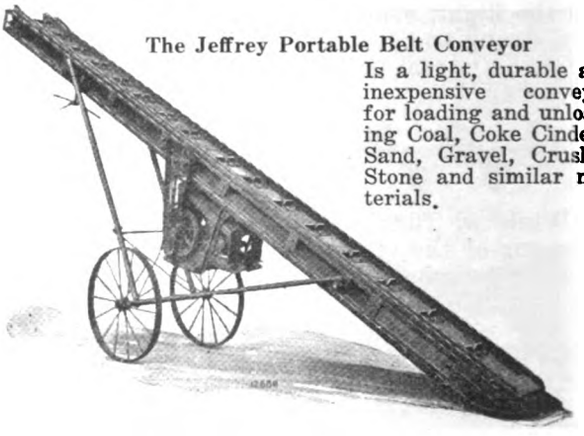
Radial Loader Handling Sand

Feeds 8 to 10 feet into the pile without the use of any mechanical device.

The Radial Loader has a capacity of 1 to 2 cubic yards per minute of Sand, Gravel, Crushed Stone, Coal and other loose material. Also built with **TANKTRED Mounting.** Catalog No. 309-A.

The Jeffrey Portable Belt Conveyor

Is a light, durable and inexpensive conveyor for loading and unloading Coal, Coke Cinders, Sand, Gravel, Crushed Stone and similar materials.



Capacity of Portable Belt Conveyor varies from 20 to 50 tons per hour. Catalog No. 369-J.

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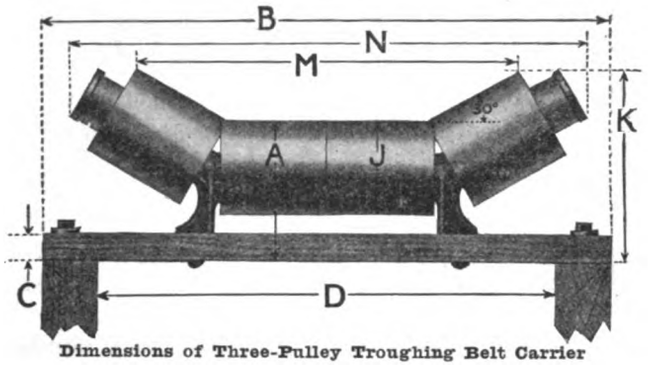
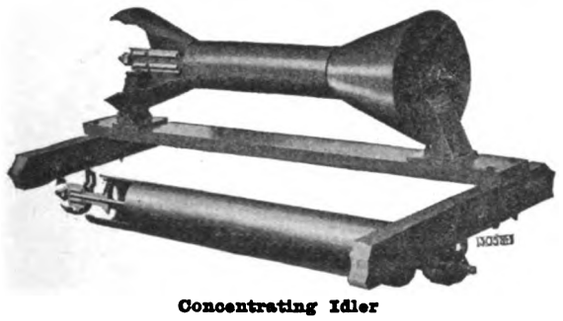


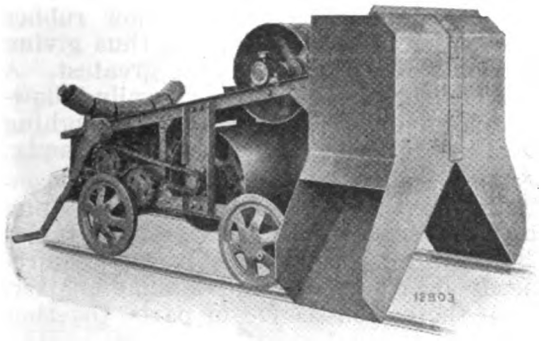
Dimensions of Three-Pulley Troughing Belt Carrier

Width of Belt, Inches	Approx. Weight with Boards, Lbs.	Dimensions—Inches							
		A	B	C	D	J	K	M	N
14	31	7 3/8	24	1 1/8	20	5	9 5/8	14	20 1/8
16	33	7 3/8	26	1 1/8	22	5	10 1/8	15 3/4	22 1/8
18	44	8 3/8	30	1 1/8	24	6	11 5/8	17 1/2	26 1/4
20	49	8 3/8	32	1 1/8	26	6	11 5/8	19 3/4	28 1/2

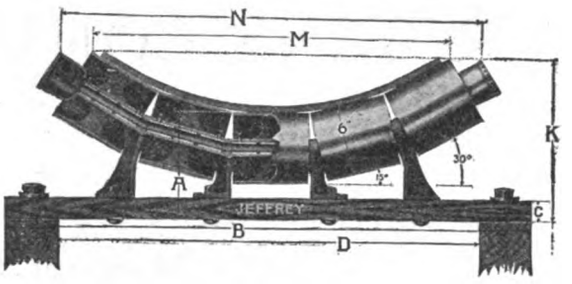


Concentrating Idler

Where economy in the consumption of power is an important factor, the new type of Jeffrey Concentrating Belt Idler is recommended. Being rugged in design, mounted upon roller bearings and fitted with a high pressure lubricating system, it is well adapted to the severe service encountered in the Metal and Quarry Industries.

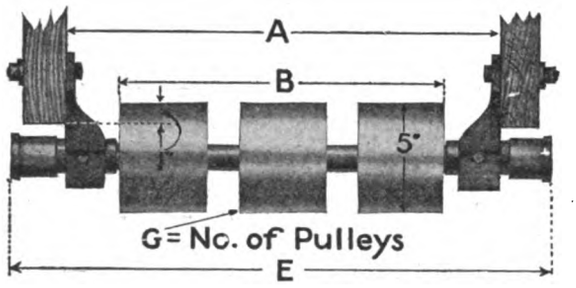


Standard Self-Propelled Automatic Reversing Tripper



Dimensions of Five-Pulley Troughing Belt Carrier

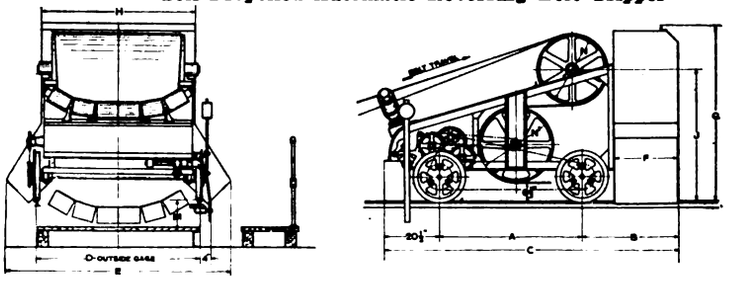
Width of Belt, Inches	Approx. Weight with Board, Lbs.	Dimensions—Inches						
		A	B	C	D	K	M	N
24	70	8 1/8	36	1 5/8	30	12 1/2	24 1/2	33 3/4
30	82	8 1/8	44	1 5/8	38	12 1/2	30	39 1/4
36	99	8 1/8	50	1 5/8	44	13 3/4	35 3/4	45
42		8 1/8	56	1 5/8	50	13 3/4	41 7/8	50 1/2
48		8 1/8	62	1 5/8	56	15 1/4	47	55 3/4

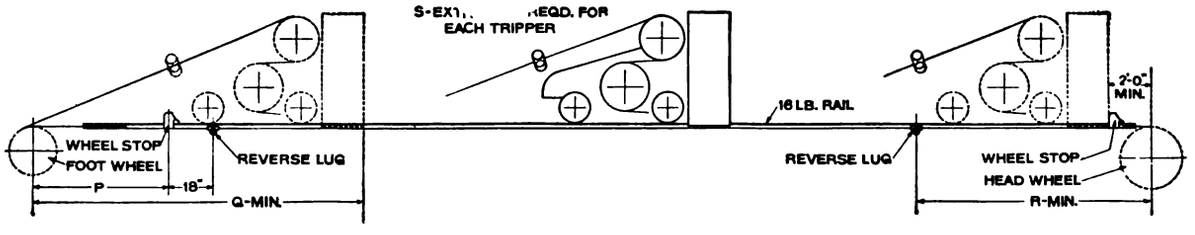


Jeffrey Belt Conveyor Return Idlers

Width of Belt, Inches	Approximate Weight, Lbs.	Dimensions—Inches				
		A For both Bottom	B Side and Hangers	E For Side Hanger	E For Bottom Hanger	G
14	23	20	15	24 1/2	28	3
16	23	22	17	26 1/2	30	3
18	28	24	19	28 1/2	32 1/2	4
20	29	26	21	30 1/2	34 1/2	4
24	38	30	25	34 1/2	38 1/2	4
30	47	38	31	42 1/2	46 1/2	5
36	48	44	37	48 1/2	52 1/2	5
42	56	50	43	54 1/2	58 1/2	6
48	58	56	49	60 1/2	64 1/2	6

Self-Propelled Automatic Reversing Belt Tripper





Dimensions of Jeffrey Self-Propelled Automatic Reversing Belt Trippers

Width of Belt	A	B	C	D	E	F	G	H	J	M	N	N1	P	Q	R	S
18"	3'- 3 "	2'- 2"	7'-1 1/2"	2'-8"	4'-7 "	14"	4'- 0 "	2'- 3 1/2"	3'- 0 "	9 3/4"	16"	18"	7'- 8 "	14'- 5 "	9'- 8"	8'-0"
24"	3'- 3 1/2"	2'- 4"	7'-4 "	3'-2"	5'-0 1/2"	16"	4'- 2 "	2'- 9 1/2"	3'- 2 "	10 "	18"	20"	7'- 7 1/2"	14'- 7 1/2"	9'-10"	8'-6"
30"	3'- 7 "	2'- 6"	7'-9 1/2"	3'-8"	5'-6 "	18"	4'- 6 1/2"	3'- 4 "	3'- 5 "	10 1/2"	20"	22"	8'- 9 "	16'- 2 1/2"	10'- 4"	9'-6"
36"	3'-10 1/2"	2'- 8"	8'-3 "	4'-2"	6'-0 "	20"	4'-11 "	3'-10 "	3'- 8 "	11 1/2"	22"	24"	9'-11 "	17'-10 "	10'- 9"	10'-6"
42"	4'- 2 "	2'-10"	8'-8 1/2"	4'-8"	6'-8 "	22"	5'- 2 "	4'- 4 "	3'-10 1/2"	11 1/2"	24"	26"	10'- 5 "	18'- 8 "	11'- 3"	11'-0"
48"	4'- 5 1/2"	3'- 0"	9'-2 "	5'-2"	7'-3 "	24"	5'- 6 "	4'-10 "	4'- 1 1/2"	13 "	26"	28"	11'- 8 "	20'- 5 "	11'- 8"	11'-6"

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ROBINS CONVEYING BELT CO.

13-21 Park Row, NEW YORK CITY

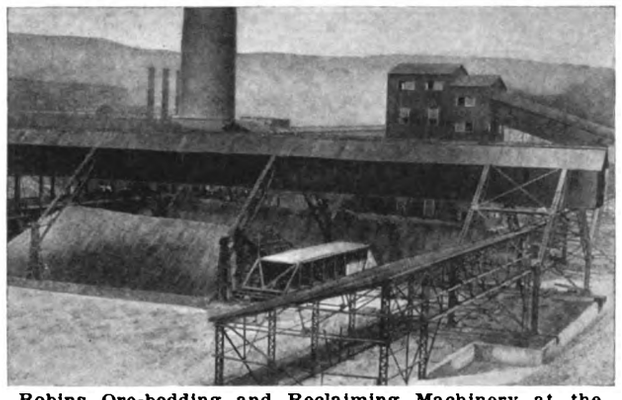
CHICAGO.....Old Colony Bldg.
PITTSBURGH.....Union Arcade Bldg.
EL PASO.....349 First National Bank Bldg.
BIRMINGHAM.....C. B. Davis Eng. Co.
PHILADELPHIA.....Widener Bldg.
BOSTON.....70 Kilby Street
SAN FRANCISCO.....The Griffin Co.
TORONTO.....Gutta Percha & Rubber, Ltd.

Manufacturers of

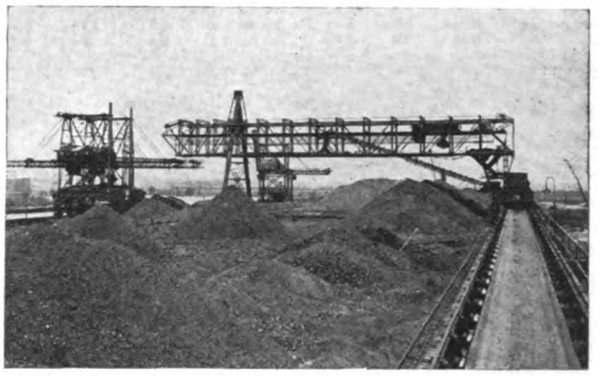
Bulk Material Handling Equipment

Products

Belt Conveyors, Belt and Bucket Elevators, Conveyor and Elevator Belts, Storage and Reclaiming Bridges, Car Dumpers, Ore Bedding Systems, Feeders, Screens, Coal and Coke Crushers, Bin Gates, Conveying Machinery for all requirements.



Robins Ore-bedding and Reclaiming Machinery at the plant of the Arizona Copper Co., Clifton, Arizona.



Robins Unloading Towers, and Stocking and Reclaiming Bridge, at the plant of the By-Products Coke Corp., South Chicago, Ill.

The Robins Conveying Belt Company is prepared to design and install conveying machinery to meet any requirement. The machinery includes belt conveyors, bucket elevators, unloading towers, storage and reclaiming bridges, car dumpers, ore bedding systems, coal and coke crushers, and the auxiliary equipment such as chutes, feeders, screens of various types, etc.

Robins conveying machinery is handling all sorts of ore, tailings, coal, coke, limestone, ashes, cement in bulk and in bags, wet concrete, sand, crushed stone, dirt, rubbish, packages of all kinds and many other materials.

Robins machinery parts are fitted for compression grease cup lubrication to protect the bearings from dust and corrosion. Consequently, troubles resulting from these causes are practically eliminated under the most severe operating conditions.

Robins Conveyor Belts are made in a number of different grades, both of the stepped-ply and straight-ply construction, each grade being designed to give the most economical service under certain operating conditions. If it is believed that none of the standard brands of belts will give satisfactory service because of unusual conditions, a special grade of belt will be designed for the work.

Robins stepped-ply belts have thicker rubber cover in the center than at the edges, thus giving more protection where the abrasion is greatest. A belt of this construction is flexible laterally, allowing it to conform to the shape of the troughing idlers, and causing it to run true even when empty.

The Robins Handbook of Conveyor Practice contains much information of interest to the designing or operating engineer. It includes a group of tables and charts concerning capacities, power requirements, speeds of conveyors and similar matter, dimensions of the various conveyor parts, together with general data on conveyor practice. We will be glad to send you a copy.

General view of the plant of the New Cornelia Copper Co., Ajo, Ariz., equipped throughout with Robins Conveying Machinery. Where material handling costs are notably low, you will always find Robins Conveying Machinery.

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THE WEBSTER M'F'G COMPANY

4500-4560 CORTLAND ST., CHICAGO

FACTORIES: TIFFIN, O., MICHIGAN CITY, IND., and CHICAGO. SALES OFFICES IN PRINCIPAL CITIES.

Elevating, Conveying and Power Transmitting Machinery

Products

Elevating and Conveying Machinery for handling all kinds of materials, including Coal and Ash Handling Equipment; Malleable Iron and Steel Chains; Screens; Coal Crushers, etc.

Ash Handling Machinery; Bearings; Belt Tighteners; Belts, Conveyor; Bridges—Coal Handling, Ore Handling; Buckets—Elevator and Conveying, Ore and Skip; Car Hauls; Car Movers and Pushers; Car Retarders; Chain—Conveyor, Rivetless and Roller; Chute Gates; Chutes; Clutches, Friction; Coal and Ash Handling Plants; Coaling Stations; Collars, Shafting; Conveyors—Ash, Belt, Coal, Pan and Apron, Retarding, Scraper, Screw and Spiral; Couplings — Shaft and Pulley; Crusher Parts; Crusher Rolls; Crushers (Mfgrs.); Drives, Rope; Dump—Crossover, Kickback and Rotary; Elevating and Conveying Machinery; Elevators—Belt, Bucket and Coal; Engineers—Consulting, Contracting and Constructing; Feeders—Apron, Conveyor, Grizzly, Reciprocating and Mine Car; Flight and Troughs; Gates—Bin; Gears and Pinions, Mitre, Bevel and Spur; Grizzlies; Hangers—Pulley and Shaft; Hoists—Skip (Mfgrs.); Hoppers—Ash; Loading Booms; Loading Machines; Mill Equipment; Pillow Blocks; Power Transmission Machinery and Supplies; Pulleys; Quarry Machinery; Rope Transmission; Screens—Perforated Metal, Revolving and Shaking; Shafting; Shafting Accessories; Sheaves; Shoveling Machines; Sprockets; Takeups; Trippers; Weigh Hoppers and Baskets.

Centrifugal Discharge Bucket Elevator

Elevators

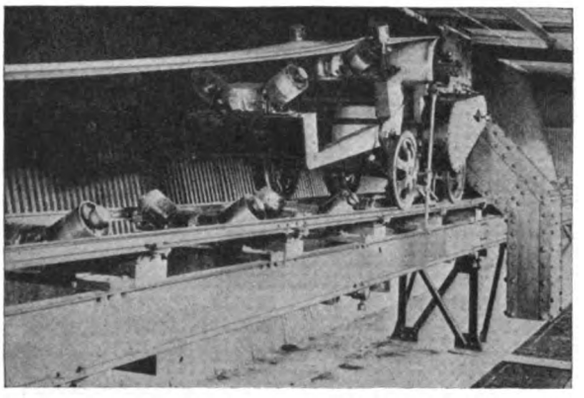
Bucket elevators of all types for handling bulk materials. Continuous and centrifugal discharge elevators for vertical or inclined lifts with either steel or malleable iron buckets.

Conveyors

Our line of conveyors is very complete and includes every type of material handling equipment of service to mine and quarry. Belt conveyors, screw conveyors, flight conveyors, apron conveyors, gravity discharge elevator conveyor and Perkins pivoted bucket carrier. Space does not permit detailed description of our many types but we can meet every requirement for equipment of this nature.

Transmission Machinery

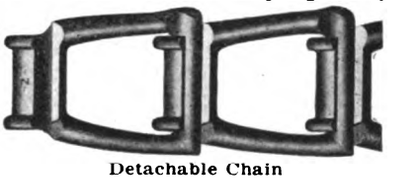
Complete line of shafting equipment for the most economical transmission of power by mechanical means. Friction clutches, gears, sprockets, pulleys, bearings, etc.



Belt Conveyor With Automatic Tripper

Chain

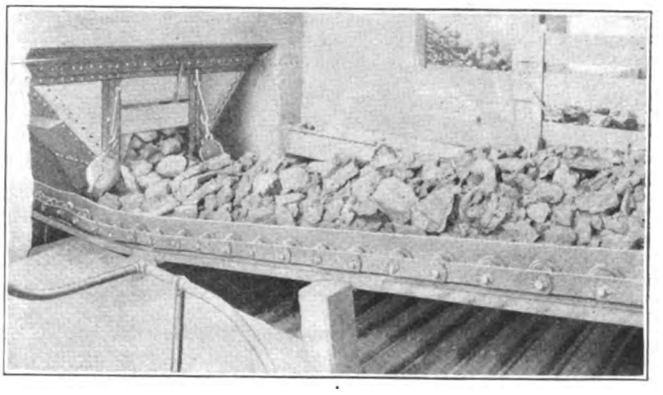
Tested chain for especially severe service for all drives at ordinary speeds; for all types of elevators; for apron conveyors; for every class of service required by the mining industry. Detachable chain interchangeable with all standard makes of corresponding size.



Detachable Chain

Sprockets

All sizes and shapes with any number of teeth for any standard pitch of chain. Webster sprockets are carefully tested with their respective chains before shipment. Chilled rim sprockets have smooth hard surfaces with deep chills which make them especially adapted to severe service. Where great strength is required, Webster sprockets can be made of cast steel. We can meet any requirement.



Apron Conveyor Receiving Ore From Hopper

Engineering Service

We maintain a staff of engineers who have had years of successful experience in designing equipment for the mechanical handling of all kinds of materials.

The John Mayne Shovel Loader

Announcing the John Mayne shovel loader which is a simple and efficient machine for loading broken ores in mine tunnels. Send for descriptive literature.

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1820-1856 North Kostner Ave., CHICAGO, ILL.

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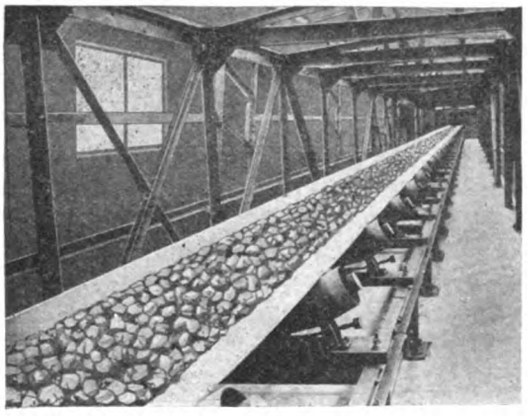
DETROIT SALT LAKE CITY SAN FRANCISCO

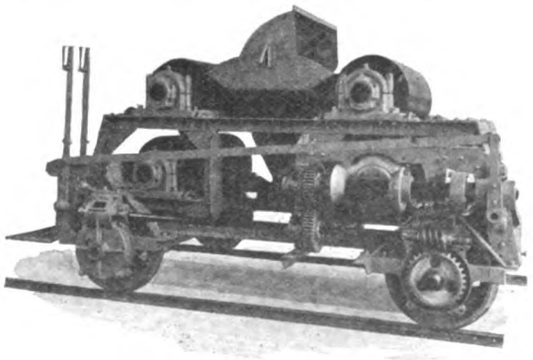
Products

Ash Handling Machinery
Ash Hoppers
Bearings
Belt Tighteners
Belts—Elevator
Bins—Mill, Smelter
Bridges—Coal and Ore Handling
Buckets—Conveying, Ore
Bunkers—Coal
Bushings—Shaft
Car Hauls
Chain
Chain—Conveyor, Rivetless
Chute Gates
Coal and Ash Handling Plants
Coaling Stations
Collars—Shafting
Conveying, Bedding and Recovery Systems
Conveyors — Ash, Coal, Pan, Apron, Retarding, Scraper
Couplings—Flexible, Shaft, Pulley
Crusher Rolls
Dryers—Ore, Steam, Rotary and Paddle
Railroad Car Dumpers
Elevating and Conveying Machinery
Elevators—Belt
Feeders—Apron, Conveyor, Grizzly, Mine Car, Ore, Reciprocating
Conveyor Flights and Trough
Gears and Pinions—Mitre, Bevel, Spur, Turbo, Reduction
Grizzlies
Hangers—Pulley & Shaft
Hoists—Electric, Skip, Steam
Rotary Kilns
Loaders—Wagon, Truck, Box Car
Loading Booms
Loading Machines
Pillow Blocks
Riveted Steel Pipe
Power Transmission Machinery
Pulleys—Iron, Steel, Wood
Pulverizers
Rollers—Wood, Iron
Screens—Incline, Lip, Perforated Metal, Wire Cloth
Shafting
Shafting Accessories
Sheaves
Sintering Plants
Speed Reducers
Coal Storage Systems
Picking Tables
Takeups—Elevator
Winches



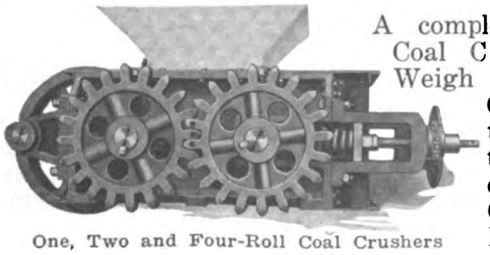
Weller Heavy Duty Belt Conveyors

We will design and manufacture complete conveying systems or supply any part of the equipment desired. Belt Conveyor Catalogue No. 35-C shows standard layouts, special installations, etc., and will be of assistance in laying out new or replacing old installations. Sent on request.



Weller Self-Propelling Tripper

Embodies features not found in any other on the market. Features fully covered by patents. Made in several styles, with steel and cast iron frames.



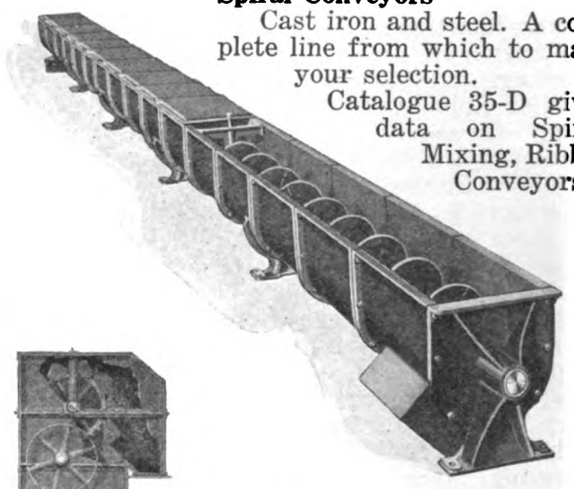
One, Two and Four-Roll Coal Crushers

A complete line of Coal Crushers, Weigh Larries and Coal Elevators illustrated and described in Catalogue No. 35-F.

Spiral Conveyors

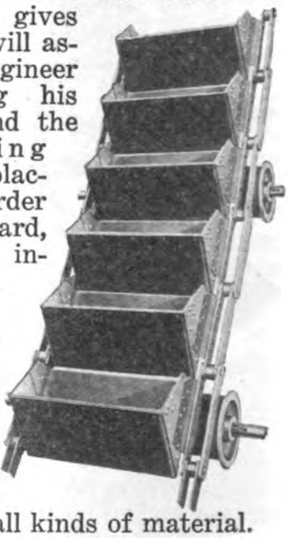
Cast iron and steel. A complete line from which to make your selection.

Catalogue 35-D gives data on Spiral, Mixing, Ribbon Conveyors.



Heavy Duty Bucket Elevators

Catalogue 35-F shows illustrations, also gives data that will assist the engineer in making his lay-outs and the purchasing agent in placing the order for standard, special, inclined, gravity discharge and pivoted bucket elevators and conveyors. We make elevators for all kinds of material.



Service

Our engineering and estimating departments are at the disposal of those in authority and responsible for the successful operation of conveying and power transmitting machinery. They will be glad to co-operate in selecting equipment best adapted to the requirements.

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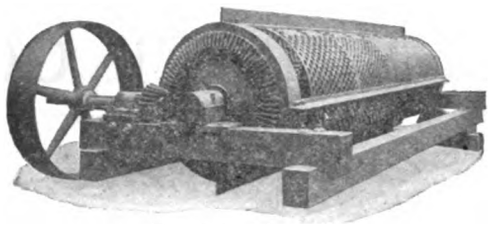
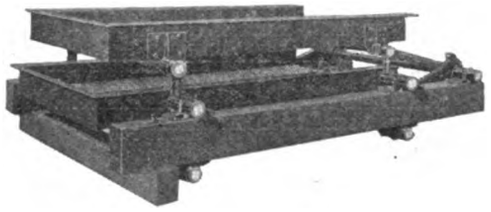


Revolving Screens

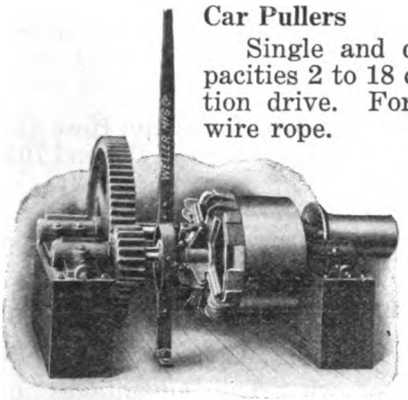


Double-Deck Reciprocating Screen

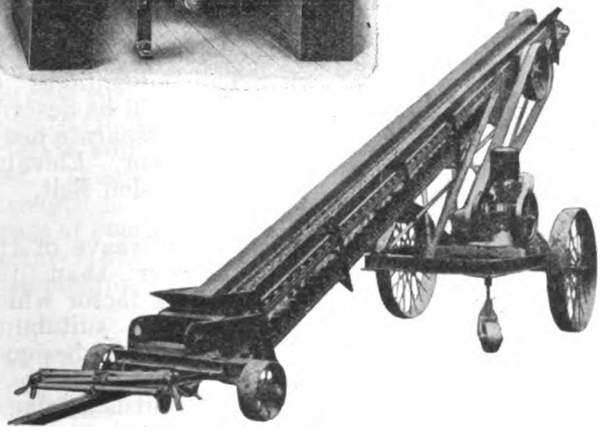
Screens of all kinds and for all kinds of materials. Specifications and lay-outs shown in our Catalogue No. 35-H, sent on request.

Car Pullers

Single and double drum. Capacities 2 to 18 cars. Gear or friction drive. For either manila or wire rope.

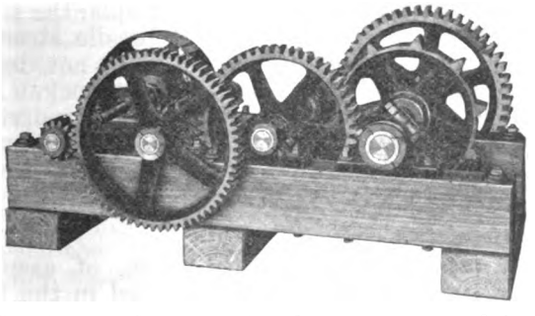


Car Pullers, Hoists and Power Shovels illustrated in Catalogue No. 35-K.



Portable Conveyors

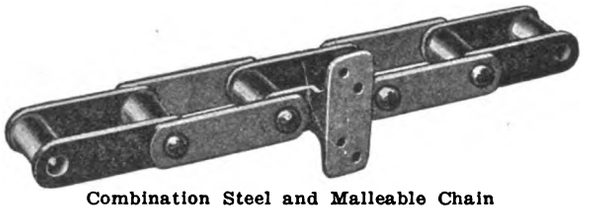
Mounted and unmounted. Let us know the kind and quality of material you want to handle.



Catalogue No. 35-A shows a complete line of transmission machinery, including Friction Clutches, Gears, Rope Drives, etc.

Weller Steel Bushed Roller Chain

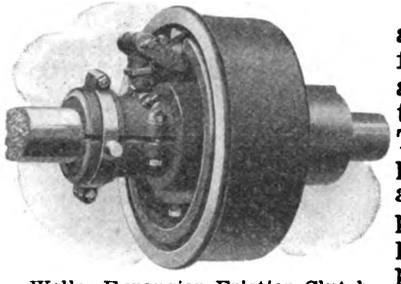
Standard Ice Chain
With and without rollers. Also used in packing plants, coal handling, etc.



Combination Steel and Malleable Chain

Weights, Working Strain and Specifications, on Malleable and Steel Chain Belting, also Conveying and Drive Chain, Sprocket and Traction Wheels, shown in our Chain Catalogue No. 35-B.

Weller Expansion Friction Clutches



Weller Expansion Friction Clutch

Has fewer parts and is more powerful for the size than any other clutch on the market today. There is but one point of adjustment and the clutch is practically f o o l - p r o o f. It gives practically the positive action of a jaw clutch combined with all the convenience of a friction clutch.

It makes no difference whether this clutch is in a dry, wet, clean or dirty place, it can be covered with dust and dirt as in a cement or stone crushing plant, or water can be dripping on it, and it will do the work just the same.

Bin Gates

We make steel and cast iron Bin Gates to m e e t most any requirement.

Also operate a Heavy Sheet Metal Department, and can supply Hoppers, Storage Bins, Chutes, Pipe etc.

Send us your specifications for prices.

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THE B. F. GOODRICH RUBBER CO.

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THE INTERNATIONAL B. F. GOODRICH CORP.
London Capetown Singapore

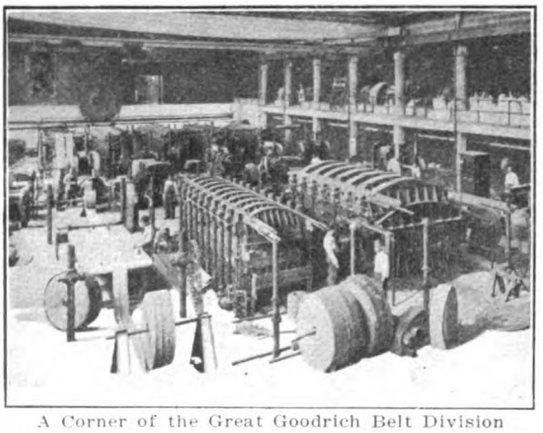
Rubber Conveyor and Elevator Belts

Mechanical Rubber Goods of Every Description

For Transmission Belts, see pages 206 and 207; for Air Drill Hose, see page 303; for Steam Hose and Packing, see pages 190 and 191; for Fire Protection and Water Hose and Couplings see pages 794 and 795.

Rubber Conveyor and Elevator Belts

A knowledge of how a rubber belt is made—what goes into it, and the function of each part—is necessary to a clear understanding of the proper type and quality of belt for each service condition.



A Corner of the Great Goodrich Belt Division

Such a knowledge cannot be obtained from the inspection of a sample or a set of samples, for, as pointed out below, it is not possible to tell by inspection whether or not the component parts of a belt are capable of performing acceptably the duties demanded of them, nor is it possible to judge of the "balance" between the different elements of the finished belt. We wish to describe briefly, therefore, the various points in belt construction, hoping that it may lead those who read this to a clearer understanding of rubber belts and their advantages.

The Duck

The basis of all rubber belts is cotton duck, woven according to the ideas of the manufacturer and the necessities of the service. In the early days of the rubber belt, comparatively little attention was paid to duck, it being assumed that weight was the only factor of importance and that the heavier the duck the better it was from a service standpoint. We became convinced after thorough study that this method of judging duck was a fallacy and that the real problem was the proportioning of the weave of the duck to the strains encountered in service and the necessity for flexibility, etc.

With the assistance of the leading duck manufacturers, therefore, we worked out special ducks for each individual type of belt. The advantages of these ducks will be described under the separate headings, Conveyor, Elevator and Transmission Belt.

Since the weave of the duck rather than the weight is the factor which determines its suitability for the service, it becomes apparent that to judge a duck by weight is a fallacy, and to specify that a duck shall be of a given weight cannot insure satisfactory performance. For example, the proportion between the size of the individual warp and filler threads has a very distinct bearing upon the transverse flexibility and longitudinal tensile strength, yet this important characteristic does not depend in any sense upon the weight of the duck. Furthermore, the amount of twist in each individual thread determines its strength, yet it is obvious that tightly twisted and loosely twisted threads weigh the same.

The only safe means, therefore, of assuring yourself that the proper duck is used in the belts you buy is to investigate the reputation of the manufacturer and the performance of his belts in services similar to yours.

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Rubber Conveyor and Elevator Belts

The Friction

The plies of duck in a rubber belt are held together by elastic bonds of rubber known as friction. The process of frictioning duck for rubber belts consists in forcing the rubber down into the meshes of the fabric by passing it between heavy rollers, and the thoroughness with which this is done and the quality of the rubber used determine the value of the friction in service.

A good friction has three characteristics—elasticity, strength and life. The elasticity of the rubber, that is the length to which each individual tendril will stretch before breaking, is most important, particularly in running belts over comparatively small pulleys, often at high speeds. In passing over the pulley, the various plies of duck are distorted and a certain amount of movement must take place if the belt is not to break. The function of the friction is to permit of this movement, and a good friction will allow considerable distortion without breaking the bond which unites the various plies. The strength of the friction is usually proportionate to its elasticity, though it is possible to make very strong frictions which are relatively inelastic and which are, therefore, almost worthless, since strength without elasticity will not prevent ply separation. The aging quality is perhaps the most important and is the one factor about friction which can be determined only by service test. It is that quality which insures elasticity in strength not only when the belt is new, but after years of operation, and the experience of the manufacturer, plus the reputation of his belts is the only standard by which aging quality can be measured.

The Cover

Covers are used on rubber belts for various purposes, depending largely upon the type of belt. In the case of transmission belts, the rubber cover is usually omitted unless unusual conditions, such as steam, acid fumes or excessive moisture make it necessary to protect the duck from deterioration. In the case of conveyor belts, covers are universally used and are proportioned in thickness and quality to the type of material handled, its abrasive quality and its weight. Thus, heavy sharp ore requires better and thicker covers than fine coal or stone. Covers on elevator belts serve the function of protecting the body of the belt from the abrasion caused by material which may fall between the belt and the pulley and that which may work its way between the bucket and the belt. The handling of wet fine material which has a scouring action on the cover requires different quality and construction from that of heavy lump material which gouges and tears, and often punches holes through the duck itself.

The Edge

No special edge construction, as a rule, is necessary for transmission belt, since good practice does not permit of the edge coming in contact with anything which would wear it, but in conveyor belt practice, edges are often torn and gouged by the action of guide idlers, etc. It is necessary that the edge be so constructed that it will not peel off, and this we have provided for by an exclusive method whereby the top cover is carried around the edge and vulcanized into the back cover, thus making a unit between the edge of the belt and the covers. This construction will not peel or tear off, but will last as long as the belt itself.

Balance

By "Balance" we mean the correct proportioning of the various parts of a belt in relation to the service which they are to perform so that no one part will out-last the other by any considerable margin. It is obviously unwise for heavy service to use anything but the heaviest best quality cover, and it is equally foolish to combine with that cover, duck too light to stand up under the strains incident to such service. Goodrich belts are so balanced in their construction that each part will give maximum of wear and that when the belt is finally worn out no one part will be capable of appreciable additional service.

CONVEYOR BELTS

The choice of a conveyor belt depends on a number of factors, chief among which are the character of the material, the size of the material, the method of feeding on the belt, the method of discharging it from the belt, the capacity and speed of the belt and the length of the belt. It is our purpose in the description which follows of our various belts to indicate in a general way the classes of service for which each is intended and to assist you, insofar as possible, in choosing the proper belt for your service. Our experience and knowledge are always

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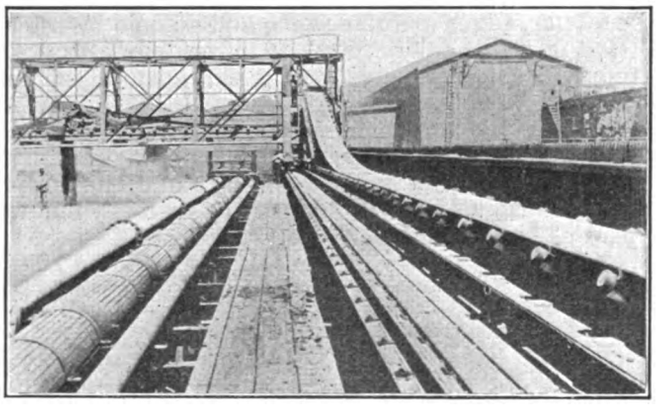
Rubber Conveyor and Elevator Belts

at your disposal, and we should be glad to consult with you at any time regarding the proper belt for any service condition which you may have or to assist you in the working out of your own special problems.

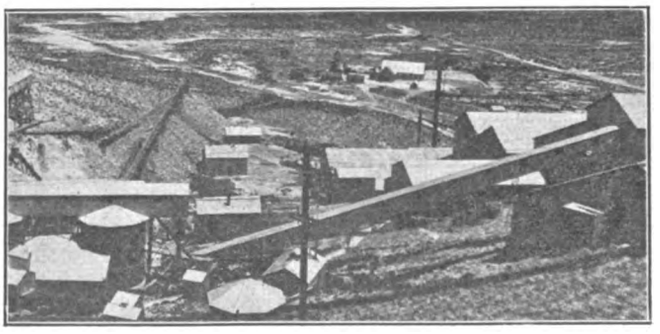


Longlife

LONGLIFE is probably the best known conveyor belt in the world. A multitude of representative industrial concerns in every corner of the globe consider it their standard, and have been using it continuously and exclusively for years.

Its field is general heavy duty service; handling heavy lump material such as run of mine ore and coal, hot materials such as cement during manufacture, very abrasive materials such as coke, etc. It is the 100% dependable belt for the place where belts are worn out quickly in continuous service, and where fractional savings in cost per ton carried are vital.

The duck in LONGLIFE is highly flexible crosswise, as well as strong lengthwise. Consequently, loaded or unloaded, it troughs of its own weight and therefore runs straight and true. Careful study



of conveyor needs has enabled us to design this duck so that every ounce of its weight is distributed to the best advantage to meet most economically the demands of heavy duty service.

Not only the **holding power**, but also the **aging quality** of the friction make LONGLIFE belt, new or old, proof against ply separation.

LONGLIFE'S cover has been so perfected that the most severe continuous abrasion produces only very slow wear. It also offers remarkable resistance to acids, heat, and in fact all agencies commonly ruinous to rubber belts. Our method of applying the cover in manufacture is such that its adhesion to the body of the belt may be depended upon throughout the life of the belt.

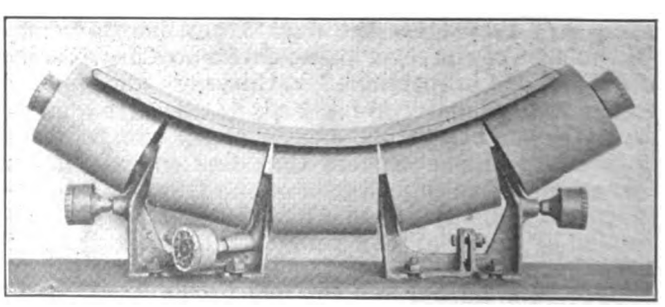
There is not a single freak feature about the construction of LONGLIFE. It is a common sense belt, designed along common sense lines. Its years of universal success are due purely and simply to its merit.

Maxecon

MAXECON spells MAXimum ECONomy in handling the finer, lighter or less abrasive materials such as sand and gravel, coal in the smaller sizes, sugar, salt, etc., and wherever the duty is not extremely exacting or the service is non-continuous.

MAXECON is built on a duck that combines strength longitudinally with transverse flexibility for troughing and has no excess weight not needed for strength and "body". Its friction and cover are of quality that insure perfect balance and enable us to offer, at moderate first cost, a belt that will last long and earn remarkably low tonnage costs in the end.

The popularity and dependability of MAXECON is indicated by the remarkable demand for it among many of the foremost manufacturers of conveyor machinery who, year after year, continue to supply it as part of the standard equipment they manufacture.



OBSERVE—The Perfect Trough of Our Belt
It Makes a Belt That—
Runs Straight and True
Is Easily Trained
Saves in Operating Expenses
Has No Edge Abrasion
Is "Satisfaction" to the Operator

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Rubber Conveyor and Elevator Belts

Super-Longlife

Where great masses of heavy, coarse material strike tremendous blows as they come upon the belt, and where the impossibility of proper supervision and up-keep combine with the most unfavorable operating conditions to ruin any ordinary belt, there SUPER-LONGLIFE finds its task.

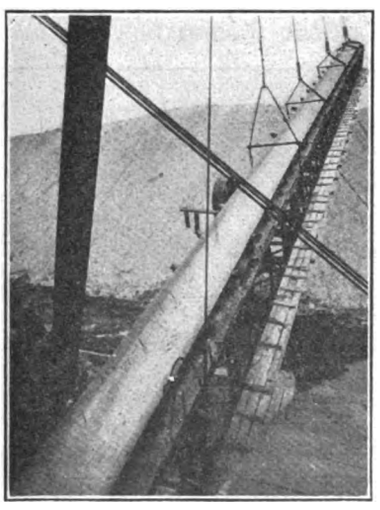
Strength is the dominant characteristic of this belt. We believe it is the nearest approach to an indestructible conveyor belt that has so far been produced.

SUPER-LONGLIFE has a specially woven duck of unequalled strength and toughness, weighing about 30% more than the heavy common ducks used in the better grades of standard conveyor belts. The plies are held together by a friction that has strength and toughness to match. To this as a body, we have added a cover of the highest wear-resisting stock and tied it on so securely by means of a special cloth insertion construction that it will never be gouged or ripped off.

Goodrich Dredge Belt

Interruptions to the operation of gold dredges are apt to be excessively costly. Besides the actual loss of time and output, repairs and replacements are unusually troublesome and expensive in the isolated locations where the dredges usually operate.

Therefore, dependability in long hard service is a requisite of all the equipment.



The Stacker Belt must have these qualities, and must remove thousands of tons of tailings day in and day out, doing its extremely heavy work with the least possible care and superintendence.

Goodrich Dredge Belt meets these requirements. It is of especially rugged construction throughout, made particularly for meeting the hardships of stacker service. It can be furnished in any desired ply and cover thickness, with either standard or raised center top cover.

Vanner Belts

Goodrich Vanner Belts are the result of years of careful investigation of the actual needs of the mining industry. They are designed and constructed with extreme care, so that the finished belt will give the even distribution of material necessary for economical operation. They meet the ideal of long life with a high efficiency of concentration.

The flanges have fabric reinforcement, and their construction is such that they are capable of withstanding sharp bending around the pulleys without distortion. Smooth or corrugated top belts can be furnished as desired.

ELEVATOR BELTS

In Goodrich Elevator Belts, you will find combined to the utmost degree, strength, wear resisting qualities and body. Whether your service be the elevating of wet fines, that bugbear of every mining man, or the handling of dry rock, Goodrich makes a belt designed and constructed to give the maximum of wear.

Our services are always at your disposal in the solution of your elevating problems.

New Mining Elevator Belt

Developed especially for handling the fine wet materials (fines) characteristic of metal mining and milling operations. This work is particularly hard on elevator belts; the fine wet ores are extremely abrasive, as well as very heavy, and the lifts are often long. Tremendous tonnages must be handled continuously, demanding belts of the utmost reliability. Ordinary belts quickly wear through their covers and plies under the severe abrasion, and once the cover is worn or torn off, water gets into the fabric and completes the ruin.

NEW MINING is built on a special closely woven, hard and tough duck, as impervious to wear and water as a belt fabric can be made. An extra cushion of extra good friction between each ply gives greatly increased flexibility, elasticity and moisture resistance.

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Rubber Conveyor and Elevator Belts

The standard construction has 3/32″ thick covers of the highest quality, perfecting to a still higher degree the wear and water proof qualities of the belt. And the cover, anchored to the belt with tie gum in which is imbedded open mesh fabric, simply will not wear, gouge or peel off.

NEW MINING has made good on its merits in many of the foremost mining plants, and has established records of unprecedented long service in several of them.

Super-Elevator

Super-Elevator is built for handling the heaviest, largest lump materials, and for resisting successfully the most damaging shocks that an elevator belt encounters in this service.

This belt is the solution of the troubles of elevator operators who are compelled to keep their belts operating where abnormally destructive conditions prevail that cannot be readily remedied.

Of all belts we know SUPER-ELEVATOR approximates most nearly an indestructible elevator belt. Extremely heavy duck is used, and the friction and cover also are of the kind that will stand punishment to the limit.

A good place to try out SUPER-ELEVATOR is where the best elevator belts you have previously tried fail to show the necessary staying qualities.

Akron

Where hard, abrasive lump material such as stone, slag, etc., are to be elevated; where lifts are long and wear and tear on the belt liable to be severe, operators have for years been demanding AKRON. Its popularity and success in dry service has been truly immense.

AKRON is built on a heavy tough duck giving unusual strength, freedom from stretch, and resistance to any forces tending to wrench or tear loose the buckets. In line with our policy of never building a poorly balanced belt, the friction and cover match up in quality with the duck.

The belt may be had with standard cover thickness (1/32″ over all) or with thicker top or back covers, or both, if the service demands.

Mor-Econ

MOR-ECON is recommended for general elevating work, in handling the lighter and less abrasive materials such as sand, clay, etc. High grade throughout, its duck has the strength and body needed for properly holding the bucket bolts, its friction is one of our best time-tried values, and its cover of the same grade that has made our MAXECON belt famous.

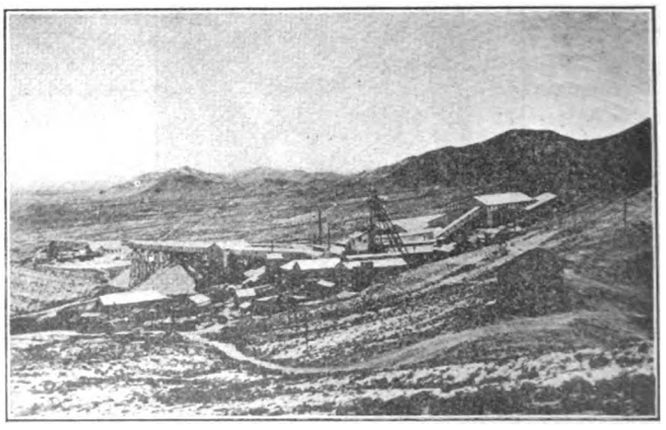
Standard 1/32″ cover on top, back and edges. Where conditions require it, we can furnish thicker than standard cover to meet any need.

Elevator Bucket Washers

Placed over the bucket bolts, these rubber washers separate the bucket from the belt, lessening the abrasive wear on the belt, with corresponding increase of efficiency and longer life.

By providing spaces between the belt and buckets, and between the washers themselves, they prevent fines from collecting and wedging between. The outlet for this material between the washers renders them immensely superior to the pieces of old belt or "scabs", sometimes used for the purpose.

Acting as a springy, elastic cushion, the washers lessen the strain on the bolts, at the moment of passing over the pulley. They also serve to seal and protect the bolt holes in the belt, keeping out moisture from the belt carcass at these holes. This is accomplished by having the washers fit the bolts tightly, and we are careful to work to exact measurements in this respect.



Can be furnished in any size. Orders should specify diameter of washer, bolt and thickness wanted. The size in most general use is 1½″ diameter, 5/16″ thick, for ¼″ or 5/16″ bolts.

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NEW YORK BELTING & PACKING CO.

New York.....91-93 Chambers St.
Boston.....65 Pearl St.
Chicago.....124-126 West Lake St.
Philadelphia.....821-823 Arch St.
Pittsburgh.....420 First Ave.

Denver.....1635 Seventeenth St.
St. Louis.....218-220 Chestnut St.
San Francisco.....519 Mission St.
Salt Lake City.....313 Felt Bldg.
El Paso.....Martin Bldg.

Conveyor Belts, Elevator Belts, Transmission Belts

For Air Drill Hose See Page 304

Products

Belting. Conveyor—Elevator—Power Transmission.

Hose. Air Drill—Water—Suction—Steam—Fire Protection—Acetylene Welding.

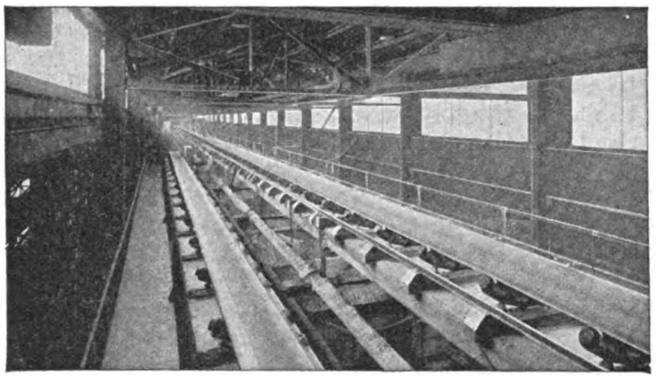
Packing. Sheet Rubber—Superheat Sheet—Piston — Hydraulic — Valve Stem—Gaskets.

Pump Valves.

Indestructible Conveyor Belting

Gives maximum service under conditions that make the use of ordinary belting more costly in the long run.

The cotton duck used in Indestructible Conveyor Belting has great tensile strength that withstands excessive strains with a wide margin of safety. The rubber friction uniting the plies of duck is particularly strong and tenacious with a remarkable ageing quality. As the life of a belt is usually limited to the life of the rubber cover, great care is exercised in selecting and compounding the stock for the cover of Indestructible Belts. The rubber cover can be relied upon to retain its strong adhesion to the fabric, and remain pliable throughout the life of the belt.



Indestructible Conveyor Belting.

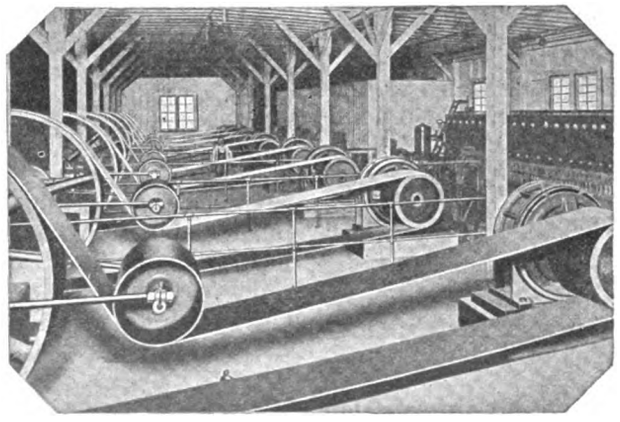
Elevator Belting

Built with the necessary strength to stand up under the tension of heavy duty. The cotton duck used in our Elevator Belts possesses unusual endurance, with strength where it is most needed —at the point where the buckets are bolted on. Particular attention is given the selection of rubber stocks for the covers of our Elevator Belts to suit the service for which they are intended.

Test Special Transmission Belting

The highest quality belting for all power transmission purposes. Made from specially woven cotton duck of great tensile strength, the plies of which are inseparably bonded with a rubber friction that retains its adhesion under the hardest service. Waterproof, flexible, strong and durable. Withstands exposure to dust, grit and moisture. Has a friction surface which gives the maximum pulley grip.

Test Special Rubber Belting shows economy in initial cost and its freedom from stretch is a protection against trouble in operation.



Test Special Belting, driving air compressor plant. Southwestern Shipbuilding Co., East San Pedro, Calif.

Packing

Packing for all purposes, steam, air, hot or cold water, acid, oil, chemicals, etc. Write for Packing Catalog.

INDESTRUCTIBLE White Sheet Packing is a rubber packing for general use.

FIRO Sheet Packing for superheat service.

COBBS Piston Packing for pressure to 150 pounds.

Pump Valves

Made from properly compounded rubber stocks to meet mine pumping conditions, ranging from valves for power plant use to valves for deep mine pumps, hot or cold water, gritty water, etc. Our experience is at your command.

Catalogs

We issue a general catalog covering all principal products and special catalogs on the following: Test Special Belting, Packing, Pump Valves.

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QUAKER CITY RUBBER COMPANY

Main Office and Factory, PHILADELPHIA

Branches

CHICAGO PITTSBURGH NEW YORK

Manufacturers of

Mechanical Rubber Goods

Products

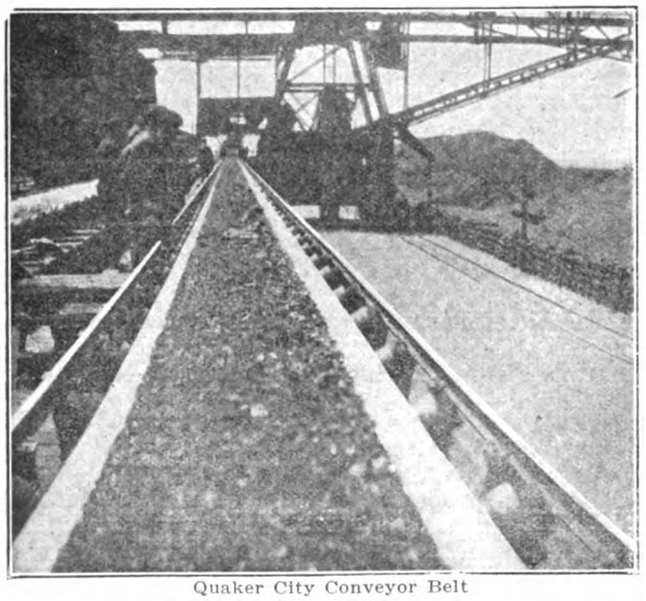
P.P.P. Rod Packing; Ebonite Sheet Packing; Ironsides Transmission Belt; Desert Conveyor Belt; Rubber Belting; Rubber Hose for all purposes; Rod and Sheet Packings; Pump Valves; Gaskets; Rubber Mats and Matting; Moulded Goods; Tubings; Automobile Tires and Tubes, and a complete line of Mechanical Rubber Goods.

Rubber Belting for Conveying of Materials

There are so many diversified places where conveyor belting can be used that it is our invariable practice to make every conveyor belt to exactly meet the working conditions.

Every conveyor belt of our manufacture is made of the proper number of plies of duck of great tensile strength, flexibility and pliability, which enable the belts to pass freely over the pulleys and to trough thoroughly. The rubber friction between the plies prevents separation and protects the fabric from the destructive effects of moisture. Our belts will trough of their own weight. They are not stiff and will not ride the side incline idlers.

Conveyor belts are furnished with reinforced covers on conveying side 1/16″ to ¼″ thick.



Quaker City Conveyor Belt

Our DESERT Conveyor Belt is designed to give maximum service under conditions that would make the use of lower grade belting considerably more expensive in the end. In all the essentials of a belt for conveying purposes, DESERT is easily the leader. DESERT is recommended for extra hard work.

QUAKER CITY Conveyor Belt has an enviable reputation among belt users for consistent performance in the belting field. It is an extra quality belt, recommended for conveying ores, sand, gravel, rock, run-of-mine coal, etc.

Consult our belting experts on any information desired on conveying problems. We stand ready at all times to assist you.

Rubber Hose

For Hot or Cold Water, Steam, Air Drill, Pneumatic Tool, Fire Protection, Suction, Chemical, Oil, and all purposes where rubber hose is used. Each grade and brand is made with special care to render the best service for which it is intended.

Rubber Belting For Power Transmission

There exists in the power transmission field so many various conditions that one grade of belting could not economically or properly do the work. For this reason we furnish a line of rubber belting so graded to correctly take care of any requirement you may have in this field.

Our three leaders IRONSIDES, QUAKER CITY and CROWN, are used extensively in the Metal Mining Industry, for main drives, compressors, crushers, and similar hard duties.

Daniel's P.P.P. Rod Packing

Unequalled for the packing against steam, water, air, ammonia and other fluids on engine, pump and compressor rods.

Furnished in all sizes from 3/16 up. Special P.P.P. for steam pressures over 100 pounds (when not superheated), high ammonia pressures, high hydraulics, very hot water, air pumps, etc. Regular P.P.P. for steam pressures of 100 pounds or less, ordinary water pressures, cold or warm, low ammonia pressures, etc.

Daniel's P.P.P. Rod Packing

Ebonite Sheet Packing

Ebonite has been found to be the most serviceable packing for high pressures, superheated steam, hot water, ammonia, oils, acids, and all other kinds of joints requiring packing.

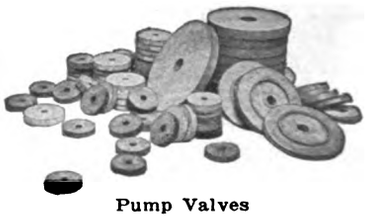
Furnished in rolls 36 inches wide and in thicknesses of 1/32, 1/16, 3/32, ⅛, 3/16 and ¼ inch. Also wire and cloth insertion if desired.

Packings

Of all kinds for piston and valve rods in ring, spiral or coil forms. Sheet Packing for flanges and joints.

Pump Valves

Valves for hot or cold water, ammonia, acids, oils, air condensers, boiler feed-water pumps, mine pumps, air pumps, etc. There is a Quaker Valve specifically made for every purpose to perform a certain duty. The following are a few of our standard stocks:



Pump Valves

No. 1100. Soft valve for cold water pressures up to 60 pounds, for water containing grit, sand, etc.

No. 1234. Medium hard valve for cold water up to 150 pounds pressure or warm water up to 170 degrees. One of our popular sellers and is, without exception, the best value on the market.

No. 1101. Hard valve made from our celebrated EBONITE stock, especially suited for work on Boiler Feed Pumps. For pressures up to 250 pounds. This valve has the reputation of being the best hot water valve on the market.

No. 2004. A high grade valve of soft red stock for Condenser Air Pump. This valve gives excellent satisfaction.

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UNITED STATES RUBBER COMPANY

1790 Broadway, NEW YORK

Branches in Every Industrial Center

Transmission Belting, Conveyor and Elevator Belts

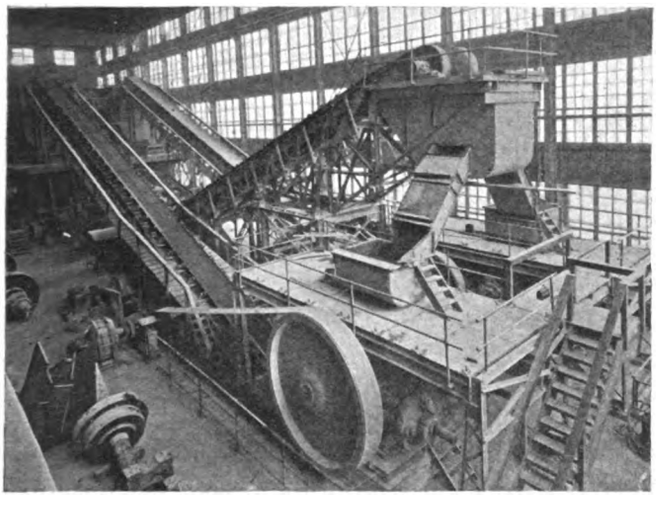
Products

Belts—Conveyor, Elevator and Transmission.

"U. S." Matchless Conveyor Belt

In manufacturing a conveyor belt that will particularly meet the requirements of the mining industry the severe conditions under which it must operate have been taken into consideration.

The "U. S." Matchless Conveyor Belt is the product of long experience and a deep knowledge of belt manufacturing. It is a high quality rubber covered belt that combines economy and long service in the handling of ore, rock, coal, slag, etc. It



"U. S." Matchless Conveyor Belt

will withstand extreme weather conditions and the tough rubber cover offers great resistance to wear and abrasion.

"U. S." Matchless is furnished with regular cover, or with special covers of added thickness for special requirements. The compound used in the covers is of extra toughened stock capable of standing up under the most severe usage.

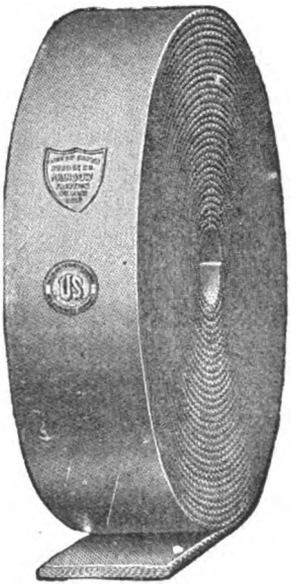
"U. S." Matchless Elevator Belt

"U. S." Matchless Elevator Belts are made with a particular eye to service. The duck is of the very highest quality and the durable rubber cover is of a specially compounded stock that affords perfect protection to the fabric.

"U. S." Matchless belts are especially adapted to work in mining sections where abrasive materials are handled and belts are subjected to considerable moisture.

"U. S." Rainbow Transmission Belting

For an all-around transmission belt that will meet the greatest number of various conditions we recommend "U. S." Rainbow Friction Surface Belting.



"U. S." Rainbow Transmission Belting

The physical qualities embodied in this belt are: pliability, making it adaptable to high speeds—weight, for steadying the belt under variable loads and strength, making it well adapted for heavy duty on main drives.

"U. S." Rainbow is a properly balanced combination of duck and rubber, uniform in construction, and possessing high tensile strength with a minimum of stretch. It grips the pulleys and delivers full power.

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Automatic Weighing Machine Company

50 Church Street, NEW YORK, N. Y.

Automatic Weighing Machines

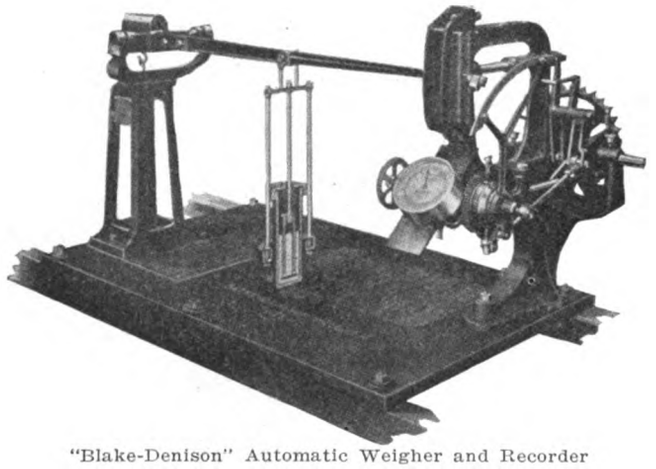
Products

"Blake-Denison" Automatic Continuous Weigher and Recorder; "Automatic" Weighing Machines; "Twin-Tank" Liquid Weigher.

"Blake-Denison" Automatic Weigher and Recorder

This machine is devised for weighing and recording in any desired denomination of weight, any quantity of powdered, granular or lump materials, such as ore, cement, coal or other material, while travelling over any type of conveyor other than the spiral screw.

The weigher consists of a weighing beam, balanced to suit the unloaded conveyor arranged underneath. The general appearance of the machine is shown in the illustration below, from which it will be seen that the principle is that of



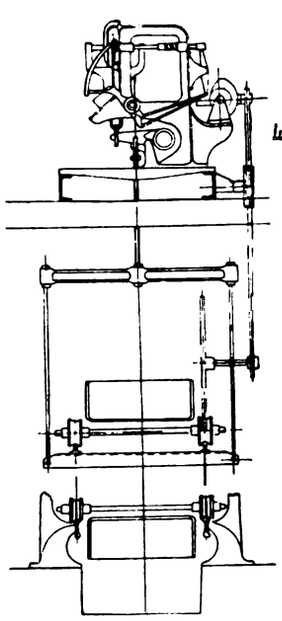
"Blake-Denison" Automatic Weigher and Recorder

suspending a short section of the conveyor and of weighing the material as it passes over it without stopping. This is effected by means of a gripping device which holds the weighing beam rigid at predetermined intervals, while, simultaneously, a measuring quadrant records the weight. Thus, if a section is 10 feet long, the machine will weigh and record the weight of the material every time the conveyor travels 10 feet, within a maximum error of ½ of 1 per cent. Oscillations of the beam are dampened by a hollow plunger attached at the middle of the weighing beam and suspended in a bath of mercury.

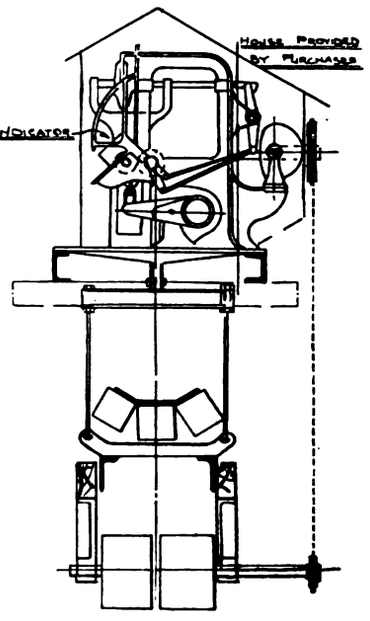
Registration—The aggregate tonnage recorder shows the total net weighings, usually in tons, with a dial showing sub-divisions, and can be consulted as frequently as necessary. Registration can be made in any unit of weight desired. There can also be provided an electrical recorder to be placed at any distance from the recorder, records being made upon a paper chart.

Use—These continuous belt weighers are constructed to handle loads up to 1,000 tons per hour and speeds of 20 to 500 feet or more per minute. They are in use for every class of material both at home and abroad, ashore and afloat. It should be noted that the weighing machine is driven by either the upper or lower member of the conveyor, and that any type of conveyor can be used, either horizontal or inclined, as may be the most convenient for the material handled.

The following illustrations show two different applications of the "Blake-Denison" Weigher and Recorder to conveyors. Note that in one case the weigher is driven from the lower member of the system and in the other case from the upper member.



The "Blake-Denison" as Used with a Steel Tray Conveyor



The "Blake-Denison" as Used with a Troughed Band Conveyor

Accuracy—On account of the positive locking of the weighing beam, the total weight follows with mechanical accuracy. The "Blake-Denison" is guaranteed, when properly erected and operated, to weigh within ½ of 1 per cent.

The "Blake-Denison" is a legal weighing instrument in Great Britain and its Colonies, and is also in use by the United States Government.

Inquiry—As every installation presents a problem peculiar to the work the weigher is to perform, and in order to quote correctly, it is necessary that the following information be supplied:

1. Location of weigher.
2. Type, width, maximum carrying capacity, and speed of the conveyor in feet per minute and whether level or inclined.
3. Dial and counter graduations desired.
4. Detail drawing showing cross-section of the conveyor.

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MERRICK SCALE MFG. COMPANY

178 Autumn Street, PASSAIC, N. J.

CABLE ADDRESS
"Weightom, Passaic, N. J."

CODES:
A. B. C., Western Union

Designers of Conveyor Weighing Installations

THE WEIGHTOMETER

Weighing Materials in Transit

The Merrick Conveyor Weightometer is an adaptation of a platform scale designed for the automatic weighing of conveyor handled materials while in transit. Where time as well as accurate weight is an important factor in the loading, unloading or transporting of materials by conveyors, the Weightometer meets the requirements. It records the weights with a guaranteed accuracy of 99%, without hindering in any way the handling of the materials.

Uses

Some of the materials handled are as follows: Ores of all kinds, such as Copper, Zinc, Iron, Pyrites, Lead, Tin, Aluminum, Gold and Silver, Concentrates, Limestone, Calcite, Rock, Sand, Gravel, Sulphites, Caliche, Coal, Coke, Paper and Cement Mill Products, etc., etc.

The Merrick Method

The Merrick Weightometer is designed for use with any size or style of belt or pan conveyor. It will weigh successfully any material which can be carried by the conveyor.

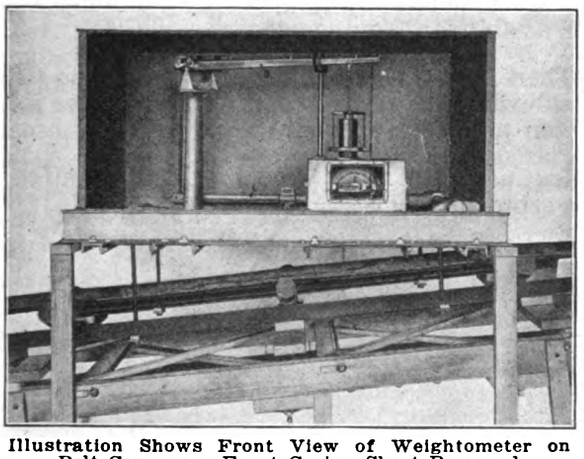
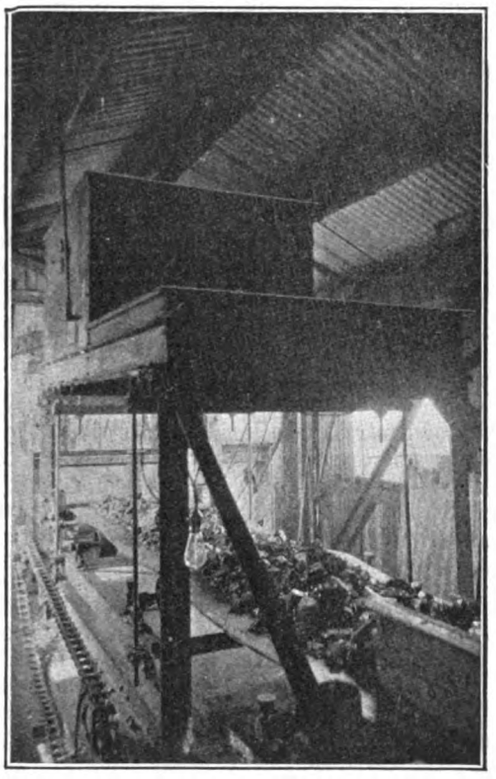


Illustration Shows Front View of Weightometer on Belt Conveyor—Front Casing Sheet Removed

A section of the conveyor belt is supported on a floating platform. This platform is hung on compound levers and balanced by an iron float in a cylinder of mercury. The movement of the float is a direct measure of the weight on the conveyor belt. An integrator multiplies this weight by the speed of the conveyor. The sprocket chain drives the integrator from the return belt of the conveyor.

Design

Since it is very seldom that any two conveyors are alike in all characteristics, each Weightometer is designed to suit the particular conveyor on which it must be installed. Being adapted principally for use on belts, the machine can be fitted for practically all inclinations, sizes, types, capacities and speeds compatible with conveyor practice.



Typical Installation of Merrick Conveyor Weightometer

In order to render installation by purchaser easy, machine is made one of mechanical movements throughout. Thus it is easy for any intelligent mechanic to readily understand the function of each part, to operate and to adjust whenever necessary. This mechanical simplicity accounts in part for the low maintenance cost.

Essential Features

The important advantages of the Merrick Weightometer are: easy installation; automatic operation; no expense for attendance; durability; simplicity; sheet iron enclosure for all working parts, thereby eliminating exposure to dust and interference by tampering; weighing without interruption of conveyor service, and a high degree of accuracy, whether the load be intermittent or uniform.

The Weightometer is also adaptable to cable car and aerial tramway installations.

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Schaffer Engineering & Equipment Company

General Offices
2828 Smallman Street
PITTSBURGH, PA.

Weighing and Compounding Machines

Products and Services

Poidometer, for Weighing and Compounding materials.

Continuous Lime Hydrator.

Industrial Engineers, specializing in the Nonmetallic Mineral Industries. Calcining Systems, Hydrating Systems.

The Poidometer

For use where materials up to 4-in. cubes are required to be weighed or compounded with absolute accuracy.

It is a self-contained unit, foolproof, built for heavy service, and yet so nicely balanced that it responds to the weight of a silver dollar.

In the ordinary installation the Poidometer hopper encloses the opening in the material bin. Where a continuous and uniform flow of material is required, the tonnage (or fraction) per hour is reduced to pounds per running foot of belt, to which the calibrations on the scale beam correspond.

Thus, if the weight on the scale beam is set at 15 lbs., it will require exactly this weight per foot of belt to balance the beam, and if the speed of the belt is regulated to say, 40 f.p.m., the Poidometer will deliver 10 lbs. per second, 600 lbs. per minute, or 18 tons per hour, with a guaranteed accuracy of not less than 99½%.

A variation in the tonnage is possible by shifting the scale beam weight, which can be locked in place if desired.

The Poidometer will automatically refuse to operate unless it receives the weight of material called for on the scale beam.

The material is prevented from clogging or bridging by an agitator in the Poidometer hopper, which makes a half revolution and reverses itself.

A Productometer attachment records the feet of belt travel, and thus the weight of the material handled in a given time.

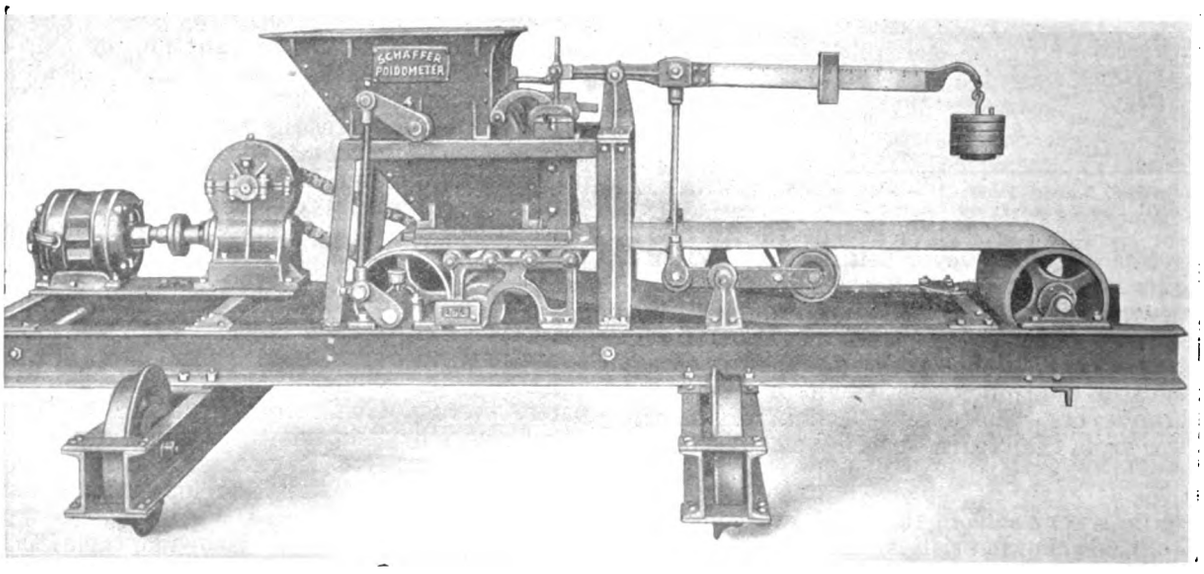
Our Weighmaster attachment converts the Poidometer into a batch weigher.

Liquidometer Attachment—This adjunct to the Poidometer delivers liquids in proportion to solids, or the process can be reversed so that solids will be delivered in proportion to liquids.

Poidometers are equipped with automatic controls as standard equipment.

There is nothing about the Poidometer to get out of order, and users report that machines in use for ten years have cost not one cent for repairs.

Let us solve your weighing, compounding or tempering problems.



The Poidometer

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DINGS MAGNETIC SEPARATOR CO.

General Office and Works
MILWAUKEE, WISCONSIN

NEW YORK	DENVER	RICHMOND	DETROIT	CHICAGO
52 Vanderbilt Ave.	1718 California St.	1905 E. Main St.	805 Hammond Bldg.	616 S. Michigan Ave.
PITTSBURGH	CLEVELAND	ST. LOUIS	EL PASO, TEXAS	
1522 Oliver Bldg.	730 Engineers Bldg.	1004 Federal Reserve Bldg.	1st National Bank Bldg.	

Magnetic Pulleys and Magnetic Separators

Products

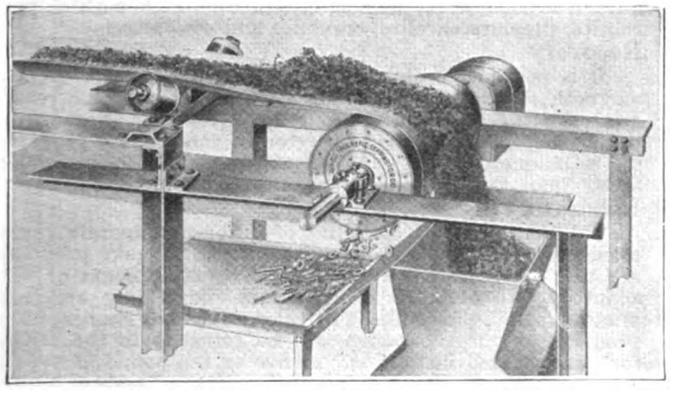
Magnetic Head Pulleys; Magnetic Separators for Iron, Steel and Brass Foundries, and for Reclaiming Metals; Suspended Type Magnets; Magnetic Chutes; Launder Magnets; High Intensity Separators for Weakly Magnetic Minerals, Both Dings and Rowand-Wetherill Types; Magnetic Drums for Wet or Dry Concentration of Iron Ores; Complete Plants for Magnetic Concentration; Davis Magnetic Tube Concentrators for Laboratory Work Upon Magnetic Ores; Electro Magnets; Conveyor Magnets; Safety Magnets; Magnetic Spouts; Standard and Special Separators; Crusher Protectors; Magnetic Log Washers.

Magnetic Pulleys

Magnetic Pulleys are used in crushing plants to remove iron and steel from the ore and to protect the crushing machinery from breakage. They are also used in concentrating magnetic iron ores.

The DINGS MAGNETIC PULLEY is designed in accordance with modern electrical practice and from the results of special investigations and tests.

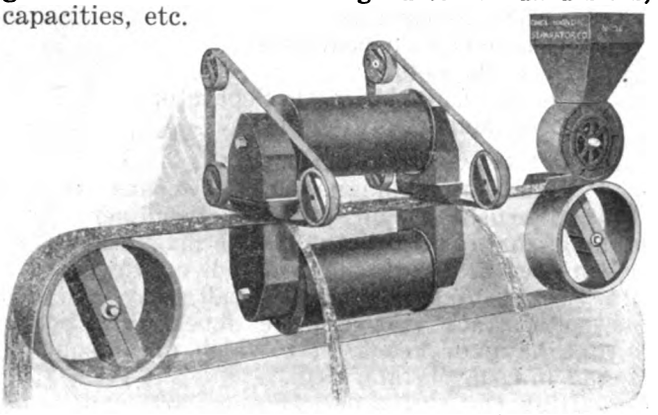
The coils are impregnated by vacuum and pressure, with a high melting point insulating compound. Impregnation has several advantages other than increasing the di-electric strength of the insulation. Unimpregnated coils are poor conductors, and frequently the temperature, of hot points at the center of the coil, is high enough to char the insulation. Impregnated coils have good radiating properties, and a very slight rise in temperature in the interior. Consequently, our pulleys are not subject to breakdowns and short circuits, such as are liable to occur in the unimpregnated types.



Dings Pulley Type Magnetic Separator. Showing How Tramp Iron is Removed from Conveyed Material.

Another advantage is, that our coils are impregnated in place, cementing the coils to the cores. This construction prevents shifting of coils, and cutting of connections, as well as excluding moisture, and so-called "sweating".

These are a few of the improved features found in DINGS MAGNETIC PULLEYS, Bulletin 25 gives full information in regard to standard sizes, capacities, etc.



Principle of Operation Rowand-Wetherill Separators.

Magnetic Concentration and Separation

Magnetic separation is used for the separation of minerals which are susceptible to a magnetic force from those which are not attracted. It is also applied to minerals which have different degrees of magnetic susceptibility. It is particularly valuable where the minerals have approximately the same specific gravity.

The following table gives some of the separations that are made by magnetic machines:

MAGNETIC MINERAL	TYPE OF ORE	PURPOSE OF SEPARATION AND REMARKS
Magnetite	Iron Ore	Concentration low grade Iron Ores
Pyrites*	Lead Zinc Ores	Removal of iron penalised by zinc smelters
Wolframite	Tungsten Ores	Raising grade of ore and removing tin
Ilmenite	Monazite Sands	Producing clean concentrate high in Thorium
Iron Minerals	Corundum	Producing high grade abrasive
Garnet	Garnet	Clean Garnet for abrasive
Pyrrhotite	Lead Zinc Ores	Raising grade and removing iron penalities
Pyrites*	Tin Ores	Raising grade of tin concentrates
Siderite	Clay	Improving refractory qualities
Garnet	Scheelite	Improving grade
Chromite	Chromite	Chromite from other heavy minerals
Marmatite	Zinc Ore	Magnetic Blende from Pyrites
Iron Minerals	Silica	High Grade Glass Sand
Epidote	Zircon	High grade Zircon concentrate
Pyrolusite	Manganese	Removing Silica which is non-magnetic
Franklinite	N.J. Zinc Ores	Separating complex Zinc manganese Ores of the same specific gravity
Rhodonite	N.J. Zinc Ores	

*Requires a skin roast to convert into magnetic sulphide.

Laboratory Tests

We have a complete testing laboratory in our Milwaukee factory. Samples will be separated for those interested. There is no charge or obligation for this service.

Facilities

We are prepared to furnish either standard or special types, for wet or dry work, with low, medium or high intensity magnetic fields. We are specialists in magnetic separation and make the installation of magnetic separating equipment and the solving of magnetic separation problems our sole business.

Bulletins sent on request.

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MAGNETIC MANUFACTURING CO.

Main Office and Works

736 WINDLAKE AVE., MILWAUKEE, WIS.

Branch Offices

NEW YORK CHICAGO ATLANTA CINCINNATI PHILADELPHIA
PITTSBURGH CLEVELAND ST. LOUIS LOS ANGELES BUFFALO

"High Duty" Magnetic Pulleys and Magnetic Separators and Special Magnetic Equipment

Products

Magnetic Pulleys;
Magnetic Separators;
Magnetic Ore Concentrators;
Safety Magnets;
High Intensity Magnetic Separators;
Special Magnetic Equipment.

"High Duty" Magnetic Pulleys

"High Duty" Magnetic Pulleys are used to protect crushing and grinding machinery from damage due to stray iron. These magnetic pulleys when used as head pulleys of belt conveyors feeding the crushing plant, remove all stray iron such as bolts, track spikes, mule shoes, drill points, sledge hammer heads, etc., which are frequently found in coal, ore and rock.

"High Duty" Magnetic Pulleys are made in all diameters and for all belt widths from 12″ to 60″ and can be installed in place of the ordinary cast iron head pulley of a belt conveyor. Where no belt conveyor is available, we usually furnish a complete Magnetic Pulley Separator. This separator consists of a short belt conveyor mounted on a steel frame, and having a magnetic pulley as a head pulley.

Operation

As illustrated by Fig. 101, the operation of "High Duty" Magnetic Pulley is extremely simple. The Magnetic Pulley is used as the head or driving pulley of a belt conveyor.

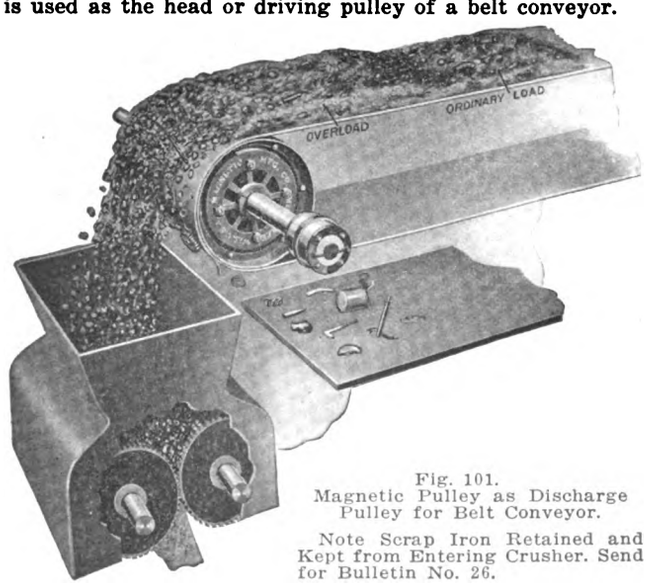
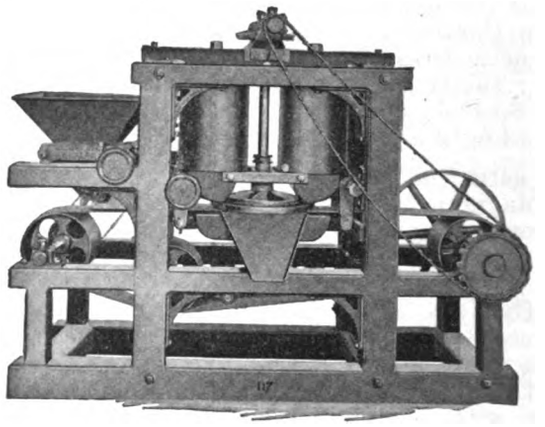


Fig. 101.
Magnetic Pulley as Discharge Pulley for Belt Conveyor.

Note Scrap Iron Retained and Kept from Entering Crusher. Send for Bulletin No. 26.

The material is discharged downwardly as it passes over the magnetic pulley and any iron contained therein is attracted by the powerful magnetic pull and held firmly against the surface of the conveyor belt, and is discharged underneath the pulley as the belt leaves the pulley surface. The magnet coils in the pulley are energized by direct current. No breaking of contacts or scraper is necessary to effect the discharge the iron being gradually carried out of the magnetic field.

Because of its superior design, and construction, the "High Duty" Magnetic Pulley is from 25% to 50% stronger than any other magnetic pulley of equal size. It is the only ventilated magnetic pulley on the market. Because the "High Duty" Magnetic Pulley is stronger its capacity is larger and a larger overload can be taken care of.



"High Intensity" Magnetic Separator.
Send for Bulletin "D".

"High Intensity" Magnetic Separators and Magnetic Ore Concentration

Magnetic Separators and Ore Concentrators are used for various purposes in metal mines and concentrating mills for concentrating such minerals as are magnetic or in removing from concentrated ore such impurities as are magnetic.

Among the ores and minerals which are susceptible to magnetic treatment, the following are fair examples. Lead and zinc sulphide, manganese, cassiterite, pyrite, nickel, garnet, chalcopyrite, monozite, wolfromite, hematite, pyrrhotite, ilmenite sheelite, chromite and graphite.

Recovery

It is possible to obtain recoveries of 98% and over in a magnetic separating plant. As a matter of fact such recoveries are the rule rather than the exception. Because of the high recovery, the cost per ton of concentrate produced by a magnetic separating plant is usually considerably lower than that obtainable by any other method.

Laboratory Test

The magnetic susceptibility of different minerals varies considerably and it is therefore advisable to make preliminary test to determine the type of Magnetic Separator best adapted. We maintain a laboratory for testing ores and minerals and will make such tests free of charge. The products of our separation will be returned to the sender for analysis and inspection. A five or ten pound sample is usually sufficient for making the necessary tests.

Magnetic Separators and Special Magnetic Equipment

We manufacture certain standard types of Magnetic Separators which are adapted to a variety of conditions. When the standard type of Magnetic Separator cannot be efficiently adapted to a particular problem we are prepared to design and build a special magnetic separator and magnetic equipment to meet the individual requirements.

BULLETINS DESCRIBING THE ABOVE MAY BE HAD UPON REQUEST

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SECTION XVIII

Cyanidation and Hydrometallurgy

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Caldwell, W. E. Co., Inc.
Colorado Iron Works Co.
Dorr Company, The
Filter Fabrics Co., The
Lungwitz, Emil E.
National Tank & Pipe Co.
Pacific Lumber Co., The
United Filters Corporation
United Lead Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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A DESCRIPTION OF THE CYANIDE PROCESS

The cyanide process for recovering precious metal values from the ores is based on the fact that gold and silver in fine particles is readily soluble in a comparatively weak solution of sodium or potassium cyanide.

Cyanide, the commercial cyanide salt of sodium or potassium, is a combination of either of these last mentioned metals with another chemical combination of carbon and nitrogen called cyanogen. Commercially it has the appearance of white rock salt and is shipped in metal drums.

The process is based on delicate chemical reactions and with certain ores these become very complicated. They can easily be brought about with a small sample of ore in the laboratory, but when the scale of these reactions is so increased as successfully to treat the daily ore production of a mine the chemical end of the process becomes subordinate to the mechanical one of handling and treating each day's output of the mine.

To do this successfully a large quantity of special apparatus has been designed. This shows a high degree of efficiency when handling ores of the nature for which it is designed; but gives very unsatisfactory service when working under conditions other than these. Very often apparatus is blamed for poor work when on close investigation it is found that the nature of the product it is handling has changed owing to a change in either the physical or chemical properties of the ore.

Before a prospective purchaser of a cyanide plant considers buying any apparatus he should first accurately sample the ore that he proposes to treat by the cyanide process. In doing this he should use every precaution to obtain an accurate sample, as a little carelessness at this point will seriously affect the operation of the mill. This sample should then be sent to an expert for careful examination and study as to its physical and chemical adaptability to successful treatment by the cyanide process. The recommendations of this expert and his design should be rigidly adhered to, as the fine reactions of the laboratory can only be obtained in the mill by closely following the directions of the man who has studied the ore and has determined how to treat it.

Mills in general may be divided into two classes, either "sand" plants or a "slime" plants, or as in many cases, a combination of these two. The nature of the ore and the cost of power determine which method should be used, but in general free milling ores are handled by a combination of the two methods. Certain soapy and soft ores are particularly adapted for treatment by the slimes process.

A free milling ore containing coarse and fine gold is first crushed by the usual methods and passed over amalgamating plates, where the coarse gold is removed and the residue passed on to a classifying apparatus which separates the slimes from the sands. These two products are handled in different parts of the mill in the same general way except that the nature of the slime product is such that, to secure contact of solution with all gold particles, agitation by various methods is required. The sand product is run through launders to leaching tanks filled with a cyanide solution of determined strength and is allowed to percolate until the precious metals are in solution. This leaching period varies from two to ten days.

The enriched effluent or percolated solution from the sand tanks passes direct to the gold tank prior to precipitation. The sands, before being discarded, are washed with water, the amount added being equal to the loss of water in the tailings.

The extraction of values in the slime pulp largely takes place during agitation, the time required for agitating being governed by the character of the ore treated. If one of the many makes of filter presses is used for recovering the dissolved values, some form of thickening is provided before filtering. The enriched solution from the filter press is handled in the same manner as the effluent from the sand tanks and the slime cake after being washed passes to the dump as tailings. Where the slime values are recovered by Continuous Counter-Current Decantation a filter is not used except where the ore treated requires a very strong cyanide solution. In such cases the filter acts only as a dewaterer.

In the process of Continuous Counter-Current Decantation as used today, the entire ore is ground to a fine sand or slime. A series of thickeners is arranged in such a manner that the solids, with a small portion of solution, pass successively from one thickener to the next, finally being discharged as tailings. The main body of solution moves in the opposite direction to the course of the ore and is gradually enriched. By each step in the system a large amount of low grade solution is mixed with a small amount of higher grade solution, so that the values of the solution entering each successive thickener with the solids are materially reduced.

The gold solution which contains the precious metal value of the ore is then brought into contact with the zinc either in the form of dust or shavings. Bright, fresh zinc shavings in long hair-like ribbons are packed into compartments of the zinc boxes and the gold solution is passed through these compartments, during which process the gold values are precipitated on the zinc shavings in the form of a black precipitate. The barren solution, on emerg-

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ing, is returned to stock solution tanks and brought up to working strength by addition of fresh cyanide. The precipitate from the zinc boxes is carefully cleaned up, and retorted into bullion ready for shipment to the refinery, where the pure metal is recovered.

The foregoing is only a rough outline of the cyanide process, but in general mills are operated as described. Variations are introduced to handle certain abnormal conditions either in the nature of the ore, operating costs or initial investments in plant.

Reference Tables and Information

Cyanides

Cyanide of potassium—KCN or KCy.

Cyanide of sodium—NaCN or NaCY.

Cyanogen is composed of carbon and nitrogen, both together forming a composition for which the chemical formula "Cy" is used, and which in its action is similar to one single element.

Cyan (ogen) ide of potassium and cyan (ogen) ide of sodium are combinations of cyanogen, with the basis potassium and sodium, respectively, the latter only acting as carriers for the cyanogen.

The action of the cyanides in the extraction of gold and silver from their ores is based on the fact that they form with these precious metals soluble double compounds.

Testing Cyanide

The standard test in use is the so-called nitrate of silver test. The test is based on the fact that cyanides form precipitates with nitrate of silver when both are in solution. In practice, a given quantity of cyanide to be tested is dissolved in distilled water and titrated with one-tenth normal solution of nitrate of silver. As the curdy white precipitate, cyanide of silver, readily dissolves, as long as there is a surplus of cyanide present in the solution nitrate of silver solution is added until a permanent milky appearance is obtained. The addition of a small quantity of chloride of sodium or iodide of potassium will help to give a more visible reaction. Each cubic centimeter of normal solution of nitrate of silver is equal to 0.013 grams of pure cyanide, so that the exact strength of the cyanide is easily ascertained. It is obvious that the strength of the nitrate of silver solution may be so adjusted as to save all further calculation. This formula is also useful for estimating the strength of cyanide solution.

Although cyanide is poisonous, it can be safely handled, but care must be taken that it does not come in contact with sores and is not taken internally.

Antidotes for Cyanide Poisoning

All cyanides are deadly poisons, but the aqueous solutions used in practice are so dilute that there is little or no danger from the prussic acid evolved from them if the buildings are properly ventilated.

Acids react on cyanides, liberating prussic acid gas, which causes almost instant death when inhaled in a pure state. When diluted with air, it causes faintness, dizziness and a depressing frontal headache.

Even very dilute solutions of cyanide are poisonous when taken internally, and when they come in contact with the skin, produce in some persons an eruption of painful red boils. In cases where the hands and arms must be brought into contact with the solutions, rubber gloves, reaching over the elbows, should be provided for the workmen. Kaffir workmen are said to suffer no inconvenience whatever from the contact of their skin with cyanide solutions.

Considering the extensive use of cyanide, the number of fatal accidents is remarkably small. Up to the present time only one fatal case has been recorded in New Zealand.

In case of accident from cyanide poisoning, the following remedies are recommended: Put the patient into a hot bath, and apply cold water to his back and neck. In case of internal poisoning vomiting should be induced by emetics or by physical means.

Freshly precipitated carbonate of iron, obtained by mixing equal quantities of sodium carbonate and ferrous sulphate, is recommended for internal use.

If the poisoning is the result of inhaling prussic acid gas, it is advisable to make the patient inhale a small quantity of chlorine gas, ammonia or ether. The chlorine gas can be quicky made and applied by sprinkling a little bleaching powder on a piece of flannel moistened with acetic acid, and then holding the flannel to the nostrils of the patient.

How to Determine Purity of Potassium Cyanide

Take a sample of the KCN to be tested across the thickness of the cake. Reduce this sample by crushing to a fine powder. To one gram of this reduced sample add 100 c.c. of distilled water. Take 10 c.c. of this solution and titrate it with standard silver nitrate. The number of c.c. of silver nitrate required to produce a permanent precipitate multiplied by five will give the percentage of KCN contained in sample.

The above is not a determination of actual cyanogen present, but a simple test to give working value of cyanide.

Strength of KCN Solution

To 1000 c.c. of distilled water add 6.535 grains of c.p. silver nitrate and standardize with a known strength of cyanide solution.

For determining the amount of cyanide in solution, take 10 c.c. of the solution (measured in a pipette) and place it in a small beaker; titrate this with the silver nitrate solution, until an opalescent precipitate appears. The number of c.c. of silver nitrate used in titration will then equal the number of pounds of cyanide in one ton of the solution.

Acidity Test

Place fifty grams of pulp in a bottle suitable for agitating; add 25 c.c. of a decinormal (N/10) caustic soda solution (as described further on) and 75 c.c. of water; agitate for an hour and filter off the solution. Titrate 20 c.c. of this filtrate with a decinormal (N/10) solution of sulphuric acid, using as an indicator phenolphthalein or methyl-orange.

Five minus the Burette reading, multiplied by 2, will give the number of pounds of lime necessary to add to each ton of ore to keep the cyanide solution at the proper point of alkalinity.

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In connection with the above, lime is presumed to be 65° pure.

It is advisable before making above acid test to agitate fifty grains of ore with 100 c.c. of water, filter and try the filtrate with litmus paper. If this shows a strong reaction, there is a quantity of free acid present, which may be removed by a water wash.

Preparation of N/10 Sulphuric Acid Solution

Add 30 c.c. concentrated c.p. sulphuric acid to a litre of distilled water; make determination of sulphuric acid and correct until solution is absolutely normal; each c.c. of this solution then contains .049 grains of H_2SO_4; add 100 c.c. of this solution to 900 c.c. of distilled water, and we have the N/10 solution, each c.c. of which contains .0049 sulphuric acid.

Preparation of N/10 Sodium Hydrate Solution

Dissolve about 56 grains of pure caustic soda in 1000 c.c. of distilled water (this will give a solution slightly stronger than normal). Titrate this with the normal sulphuric acid solution, using litmus or phenolphthalein for an indicator; make corrections and titrate again until one c.c. of this solution is equivalent to one c.c. of sulphuric acid. Add to 100 c.c. of this solution 900 c.c. of distilled water and one c.c. of this N/10 solution will neutralize one c.c. of N/10 sulphuric acid solution.

Determination of Other Contents of Ore Which Will Decompose KCN

Place 500 grams of the ore in a percolator and add 1000 c.c. of 10 pounds solution, allowing it to stand for 12 or 16 hours, and then drain slowly. Titrate the drained solution to determine cyanide contents and note loss in strength.

Make another test with a sample to which lime has been added, as determined by acid test. Note the difference between the two tests, which will represent the loss due to the presence of decomposing contents of the ore other than the acid.

If this loss is heavy, a determination must be made to ascertain the cause.

To Determine Alkalinity of Cyanide Solution

Take 10 c.c. of solution in a small breaker, and titrate it with silver nitrate for cyanide. Add as much more silver nitrate as used in the titration, then add an excess of potassium ferro-cyanide; add a drop or two of phenolphthalein and titrate with N/10 sulphuric acid solution.

If the solution contains much zinc, it will be necessary to filter before titrating.

The Burette reading multiplied by .0112 will give the percentage of protective alkalinity of the cyanide solution, which should be about 2%.

Amount of Gold and Silver in Cyanide Solution

Alfred Chiddy's Method—Add to four assay tons (or more) of the solution 10 c.c. of 10% solution of lead acetate; then 4 grams zinc shavings; boil a minute; add 20 c.c. HCL (strong). When action has ceased, boil again and decant from the ball of spongy lead, and wash same by decantation. Transfer to a piece of filter paper, roll into a compact ball and place (without drying) on a hot cupel in the muffle.

It is best to transfer the compact ball from the filter paper to a piece of c.p. lead foil and then cupel directly or scorify first, then cupel.

Do not add all of the 20 c.c. HCL at once, as zinc may break up on account of violent action and disintegrate the lead sponge.

Another Method—Take a piece of c.p. lead foil and form a tray about 5 inches long, 2½ inches wide and ¾ inch deep, and evaporate in this tray from one to three assay tons of the solution until dry, and then cupel the lead.

It is seldom necessary to scorify the lead before cupelling, unless the solution is very foul.

TABLES OF KCN SOLUTIONS

1	lb.	KCN	to	1	ton	water	0.05%	solution
2	"	"	"	1	"	"	0.10%	"
3	"	"	"	1	"	"	0.15%	"
4	"	"	"	1	"	"	0.20%	"
5	"	"	"	1	"	"	0.25%	"
6	"	"	"	1	"	"	0.30%	"
7	"	"	"	1	"	"	0.35%	"
8	"	"	"	1	"	"	0.40%	"
9	"	"	"	1	"	"	0.45%	"
10	"	"	"	1	"	"	0.50%	"
.5	grammes	KCN	added	to	1,000	c. c. water	0.05%	"
1.0	"	"	"	"	1,000	"	0.10%	"
1.5	"	"	"	"	1,000	"	0.15%	"
2.0	"	"	"	"	1,000	"	0.20%	"
2.5	"	"	"	"	1,000	"	0.25%	"
3.0	"	"	"	"	1,000	"	0.30%	"
3.5	"	"	"	"	1,000	"	0.35%	"
4.0	"	"	"	"	1,000	"	0.40%	"
4.5	"	"	"	"	1,000	"	0.45%	"
5.0	"	"	"	"	1,000	"	0.50%	"

From Catalog of Pacific Tank and Pipe Company.

NECESSARY INFORMATION REQUIRED BY MANUFACTURERS

It will be necessary for an intelligent offering of cyanide plant specifications to have the prospective purchaser answer the following questions and give all further information which he has available.

1. Shipping directions.
2. Capacity required (tons per day).
3. Copy of test report if any.
4. Process to be used:
   a. Wet or dry crushing.
   b. Leaching (give duration of contact).
   c. Continuous current decantation.
   d. Fine-grinding or all-slime process and kind of filter to be used (continuous vacuum, drum-type; pressure; vacuum leaf; etc.).
5. Profile of the ground at plant site, or angle of inclination.
6. Kind of power to be used:
   a. Steam (specify kind of fuel).
   b. Electricity (give voltage if continuous current; give phase and voltage if alternating current).
   c. Oil engine (give Baume gravity and B. t. u. of oil to be used; give altitude at mill site).
   d. Distillate engine (give altitude at mill site).
7. Precipitation process to be used:
   a. Zinc dust.
   b. Zinc shavings.
8. Disposal of tailing:
   a. Sluicing if water is available.
   b. Mechanical disposal by shoveling or conveying apparatus.
9. Disposal of precipitates:
   a. Oil furnace.
   b. Electric furnace.

Pacific Tank and Pipe Company.

NEW METHOD OF EVALUATING ZINC DUST

A new method for evaluating zinc dust is given in Metall u. Erz, as follows: One gram of dust, ground to 90 mesh, is shaken with 20 c.c. of water until evenly suspended. A mixture of 20 c.c. of 10 per cent. sulphuric acid and 25 c.c. of 3 per cent. hydrogen peroxide is added. Let stand and stir occasionally. All except a small amount of lead sponge should be dissolved in ten minutes. Add 20 c.c. of 40 per cent. sulphuric acid and titrate the excess hydrogen peroxide with permanganate (15 g. per liter) that has been standardized against sodium oxalate.

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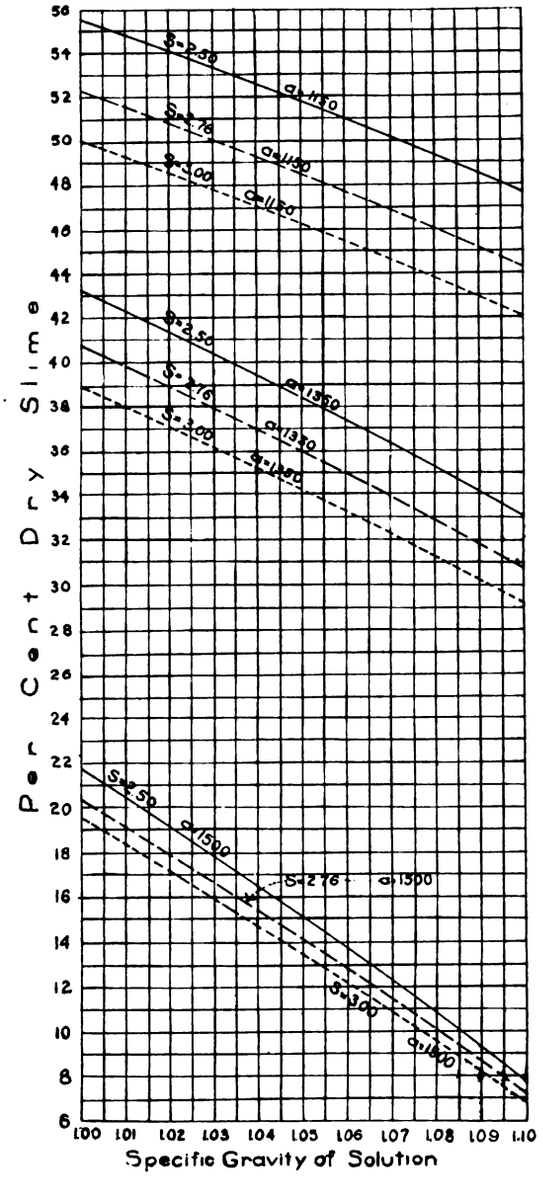
PULP CONSTANTS*

The development of the various hydrometalurgical processes for the treatment of ores has made necessary the establishment of certain constants for calculating the various factors used in the handling of ore pulps. This need was early recognized in South Africa in connection with the cyanide process, when the first serious attempts were made to treat slime. Caldecott,[1] in 1897 and 1898 published various slime pulp formulas. At a somewhat later date tables had been calculated for special cases and were in private use at a number of mills. Lamb,[2] early in 1910, published a small table showing the capacity per ft. of depth for circular tanks 12, 16, 20, 24, 28 and 30 ft. diameter, as well as weight per cubic foot in tons, cubic feet per ton, cubic feet of pulp per ton of dry slime, and percentage of water in pulps for a specific gravity of dry slime of 2.5 and for pulps weighing from 1012 to 1924 grams per liter. This table gives only approximate values. Sharwood,[3] in 1910, published a contribution upon the subject of measurement of pulp and tailing, in which he discussed sampling and the general formulas for the calculation of the constant. In this article attention was called to the desirability of preparing tables to meet special cases, and several samples of such tables were given. Caldecott,[4] later in 1910, published a table in which he combined slime and sand data. This table covered only the values for a specific gravity of dry slime of 2.7. (The term "dry slime" does not seem to be entirely satisfactory. "Dry ore" might appear to be preferable, but here a very serious difficulty arises when part of the ore is treated as slime and part as sand. On account of general usage and the lack of a better term we have used "dry slime", throughout this article). The values were necessarily taken at rather long intervals on account of the large range covered within the scope of one page. Hyder,[5] in 1911, called attention to the serious errors which may arise when the specific gravity of the solution is assumed to be 1. He also called attention to the fact that a variation in the specific gravity of the solution produces a much greater effect than a similar variation in the specific gravity of dry slime. Later in 1911, Stadler[6] published an account of an investigation carried on in South Africa on behalf of the Mines Trials Committee regarding the practical application of the specific gravity flask, in which he calls attention to the accuracy of this method of determining tonnages and to its application in the control of classifiers. Early in 1912, Allen,[7] in discussing the estimation of tonnage, gives several methods, and among others discusses the specific gravity method as applied to ore pulps. McLain,[8] in 1912, published a straight-line diagram which showed the percentage of moisture and of solids for pulps of varying specific gravities. The specific gravity of the dry slime was assumed to be 2.65. Lowden,[9] in 1912, published a table of slime-density relations, giving the number of cubic feet to make 1 ton (2,000 lb.) of wet pulp, as well as the ratio of solids to solution, and the percentage of dry slime.



*Clevinger, Young and Turner in Eng. and Min. Journ.

1Caldecott, The Solution of Gold in Accumulated and Other Slimes—Proc. Chem. & Met. Society. S. A., Vol. 2, p. 102, p. 153; Slime Pulp Formulas, p. 837.

2Lamb, Rapid Estimation of Pulp in Cyanide Tanks—Eng. & Min. Journal, Vol. 89, p. 160.

3Sharwood, Measurement of Pulp and Tailing—Mining Magazine, Vol. 1, pp. 226-230, pp. 297-305; Vol. 2, pp. 45-53.

4Caldecott, The Capacity of Circular Vats per Foot of Depth—Journ. Chem. Met. and Min. Soc. S A., Vol. 10, p. 407.

5Hyder, Specific Gravity Estimation of Pulp—Colo. Sci. Soc., Vol. 9, p. 417.

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9Lowden, A New Slime Density Table—Met. & Chem. Eng., Vol. 10, p. 869.

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Later in 1912, Stevens[10] published a straight-line diagram which was an elaboration of that given by McLain. This showed percentages of solids and ratio of solution to solids for various specific gravities of wet pulp and for a specific gravity of dry slime of 2.65.

Preparation of Detailed Tables

The range and general form of the accompanying tables were outlined in 1911, and shortly thereafter the computations were begun. Due to the large amount of work involved, which had to be done at intervals during the performance of other duties, the tables were only recently completed. Four-place logarithmic tables were employed in computing the various tables, with the exception of the table of dilutions, on account of the greater rapidity with which they could be used. The table of dilutions is intended for use in making rough comparisons, and as it is not involved in the computation of the other tables, sufficiently accurate results were obtained by the use of a slide rule. Checking the results given in the various tables by the use of the proper formulas and a five or six-place logarithmic table, or by making the calculations without the use of logarithms, may show certain of the values to be in error. This is due to the fact that the last place of any logarithmic table is an approximation, hence results obtained with a four-place table may show errors in the fourth place.

Table A. Showing the Effect of the Specific Gravity of the Solution Upon the Percentage of Dry Slime in Wet Pulp

Sp. G. of Solution	Sp. G. of Dry Slime = 2.50						Sp. G. of Dry Slime = 2.76						Sp. G. of Dry Slime = 3.00					
	Weight of 1 liter of Pulp						Weight of 1 liter of Pulp						Weight of 1 liter of Pulp					
	1150		1350		1500		1150		1350		1500		1150		1350		1500	
	P	P'	P	P'	P	P'	P	P'	P	P'	P	P'	P	P'	P	P'	P	P'
1.000	21.739	21.739	43.211	43.211	55.555	55.555	20.455	20.455	40.657	40.657	52.273	52.273	19.565	19.565	38.889	38.889	50.001	50.001
1.010	20.426	20.426	42.257	42.257	54.810	54.810	19.200	19.200	39.721	39.721	51.520	51.520	18.353	18.353	37.968	37.968	49.246	49.246
1.020	19.095	19.113	41.292	41.303	54.054	54.065	17.931	17.945	38.774	38.785	50.759	50.769	17.127	17.141	37.037	37.047	48.484	48.491
1.030	17.746	17.800	40.313	40.349	53.288	53.320	16.647	16.690	37.817	37.849	49.989	50.017	15.890	15.929	36.097	36.126	47.715	47.736
1.040	16.379	15.487	39.321	39.395	52.512	52.575	15.349	15.435	36.847	36.913	49.210	49.265	14.640	14.717	35.147	35.205	46.939	46.981
1.050	14.992	14.174	38.314	38.441	51.724	51.830	14.035	14.180	35.867	35.977	48.421	48.523	13.378	13.505	34.188	34.284	46.154	46.226
1.060	13.587	13.861	37.295	37.487	50.925	51.085	12.706	12.925	34.876	35.041	47.623	47.761	12.102	12.293	33.218	33.363	45.361	45.471
1.070	12.162	12.548	36.260	36.533	50.116	50.340	11.361	11.670	33.872	34.105	46.816	46.999	10.813	11.081	32.239	32.442	44.559	44.716
1.080	10.716	11.235	35.211	35.579	49.295	49.595	10.000	10.415	32.857	33.169	46.000	46.257	9.511	9.869	31.250	31.521	43.750	43.961
1.090	9.251	9.922	34.148	34.625	48.463	48.850	8.622	8.170	31.829	32.233	45.173	45.505	8.195	8.657	30.250	30.000	42.932	43.206
1.100	7.764	8.609	33.069	33.671	47.619	48.105	7.229	7.905	30.790	31.297	44.337	44.753	6.865	7.445	29.240	29.679	42.106	42.451

TABLE 1. PER CENT. OF DRY SLIME AND CORRECTION FOR SPECIFIC GRAVITY OF SOLUTION

Formula: $$P = \frac{100\,S\,(a-d)}{a\,(S-d)}$$

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp	2.50	Correction	2.52	Correction	2.54	Correction	2.56	Correction	2.58	Correction	2.60	Correction	2.62	Correction	2.64	Correction	2.66	Correction	2.68	Correction	2.70	Correction	2.72	Correction	2.74	Correction
1010	1.650	.1650	1.642	.1642	1.633	.1633	1.625	.1625	1.617	.1617	1.609	.1609	1.601	.1601	1.594	.1594	1.586	.1586	1.579	.1579	1.573	.1573	1.566	.1566	1.560	.1560
1020	3.268	.1623	3.251	.1615	3.234	.1607	3.217	.1598	3.201	.1590	3.186	.1583	3.171	.1575	3.156	.1568	3.142	.1561	3.128	.1555	3.115	.1548	3.101	.1541	3.088	.1535
1030	4.854	.1597	4.829	.1586	4.804	.1581	4.780	.1573	4.756	.1565	4.733	.1558	4.711	.1551	4.689	.1544	4.668	.1537	4.647	.1531	4.627	.1525	4.607	.1518	4.588	.1512
1040	6.411	.1571	6.378	.1564	6.345	.1556	6.312	.1548	6.281	.1541	6.252	.1534	6.222	.1527	6.192	.1520	6.163	.1513	6.136	.1507	6.110	.1501	6.084	.1495	6.059	.1489
1050	7.936	.1545	7.895	.1537	7.854	.1530	7.814	.1523	7.776	.1516	7.739	.1509	7.702	.1502	7.666	.1496	7.631	.1490	7.597	.1484	7.565	.1478	7.532	.1472	7.501	.1466
1060	9.435	.1521	9.386	.1514	9.337	.1506	9.290	.1499	9.244	.1492	9.200	.1486	9.156	.1479	9.114	.1473	9.072	.1467	9.031	.1461	8.992	.1455	8.954	.1449	8.916	.1443
1070	10.90	.149	10.85	.149	10.79	.148	10.73	.147	10.68	.146	10.63	.146	10.58	.145	10.53	.145	10.48	.144	10.44	.144	10.39	.143	10.35	.143	10.30	.142
1080	12.34	.147	12.28	.146	12.22	.146	12.16	.145	12.10	.145	12.04	.144	11.98	.143	11.92	.142	11.87	.142	11.82	.142	11.77	.141	11.72	.141	11.67	.140
1090	13.76	.145	13.69	.144	13.62	.144	13.55	.143	13.48	.142	13.42	.142	13.35	.140	13.29	.140	13.23	.140	13.17	.139	13.12	.139	13.06	.139	13.01	.138
1100	15.15	.143	15.07	.142	14.99	.141	14.91	.140	14.84	.140	14.77	.139	14.70	.139	14.63	.138	14.56	.137	14.50	.137	14.44	.137	14.38	.137	14.32	.136
1110	16.52	.140	16.43	.139	16.34	.138	16.26	.138	16.18	.138	16.11	.138	16.03	.137	15.95	.136	15.88	.136	15.81	.135	15.74	.135	15.67	.134	15.61	.134
1120	17.86	.138	17.76	.137	17.67	.136	17.58	.136	17.50	.136	17.41	.135	17.33	.135	17.25	.134	17.17	.134	17.09	.133	17.02	.133	16.95	.133	16.88	.132
1130	19.17	.136	19.07	.135	18.97	.134	18.87	.133	18.78	.133	18.69	.132	18.60	.132	18.52	.132	18.43	.131	18.35	.131	18.27	.130	18.19	.130	18 12	.130
1140	20.47	.134	20.36	.133	20.25	.132	20.15	.132	20.05	.131	19.95	.130	19.86	.130	19.77	.130	19.68	.130	19.59	.129	19.51	.129	19.42	.128	19.34	.128
1150	21.74	.132	21.62	.131	21.51	.130	21.40	.130	21.30	.130	21.20	.129	21.10	.128	21.00	.129	20.90	.128	20.81	.128	20.72	.127	20.63	.127	20.54	.126
1160	22.99	.130	22.87	.129	22.75	.129	22.63	.128	22.52	.127	22.41	.127	22.30	.126	22.20	.126	22.10	.126	22.00	.125	21.91	.125	21.81	.124	21.72	.124
1170	24.21	.127	24.08	.127	23.96	.126	23.84	.126	23.72	.125	23.61	.125	23.50	.125	23.39	.124	23.28	.124	23.18	.124	23.08	.123	22.98	.123	22.88	.122
1180	25.42	.125	25.29	.125	25.16	.125	25.03	.124	24.91	.124	24.79	.123	24.67	.123	24.56	.123	24.45	.123	24.34	.122	24.23	.122	24.12	.121	24.02	.120
1190	26.61	.123	26.47	.123	26.34	.123	26.21	.122	26.08	.122	25.95	.121	25.83	.121	25.71	.121	25.59	.120	25.48	.120	25.37	.120	25.26	.119	25.15	.118
1200	27.77	.121	27.63	.121	27.49	.121	27.35	.120	27.21	.119	27.08	.119	26.95	.118	26.83	.118	26.71	.118	26.59	.118	26.47	.117	26.36	.117	26.25	.117
1210	28.92	.119	28.77	.119	28.62	.119	28.48	.118	28.34	.118	28.20	.117	28.07	.117	27.94	.117	27.81	.117	27.69	.116	27.57	.116	27.45	.116	27.33	.115
1220	30.05	.118	29.89	.117	29.74	.117	29.59	.116	29.44	.116	29.30	.116	29.16	.115	29.03	.115	28.89	.114	28.76	.114	28.64	.114	28.52	.114	28.40	.114
1230	31.16	.115	31.00	.115	30.84	.115	30.68	.114	30.53	.114	30.39	.114	30.24	.113	30.10	.113	29.96	.113	29.83	.113	29.70	.112	29.57	.112	29.44	.112
1240	32.26	.114	32.09	.114	31.92	.113	31.76	.113	31.60	.112	31.45	.112	31.30	.112	31.16	.112	31.02	.112	30.88	.112	30.75	.111	30.62	.111	30.49	.111
1250	33.33	.112	33.16	.112	32.99	.112	32.82	.111	32.66	.111	32.50	.110	32.35	.110	32.20	.110	32.05	.110	31.90	.110	31.76	.109	31.63	.109	31.50	.109
1260	34.39	.111	34.21	.110	34.03	.110	33.86	.110	33.69	.109	33.53	.109	33.37	.109	33 22	.109	33.07	.109	32.92	.108	32.78	.108	32.64	.108	32.50	.108
1270	35.43	.109	35.25	.108	35.07	.108	34.89	.108	34.72	.108	34.55	.108	34.39	.107	34.23	.107	34.07	.106	33.92	.106	33.77	.106	33.62	.106	33.48	.105
1280	36.46	.107	36.27	.107	36.08	.106	35.90	.106	35.72	.106	35.55	.106	35.38	.105	35.22	.105	35.06	.105	34.90	.105	34.75	.105	34.60	.104	34.45	.104
1290	37.46	.105	37.27	.104	37.08	.104	36.89	.104	36.71	.104	36.53	.104	36.36	.103	36.19	.103	36.02	.103	35.86	.103	35.71	.103	35.56	.102	35.41	.102
1300	38.46	.103	38.26	.103	38.06	.102	37.87	.102	37.68	.102	37.50	.102	37.32	.102	37.15	.102	36.98	.102	36.82	.102	36.66	.102	36.50	.101	36.34	.101
1310	39.44	.102	39.23	.102	39.03	.101	38.83	.101	38.64	.101	38.45	.101	38.27	.101	38.09	.101	37.92	.100	37.75	.100	37.59	.100	37.43	.100	37.27	.100
1320	40.40	.100	40.19	.100	39.98	.099	39.78	.099	39.58	.099	39.39	.099	39.20	.099	39.02	.099	38.84	.098	38.67	.098	38.50	.098	38.33	.097	38.17	.097
1330	41.34	.098	41.13	.098	40.92	.098	40.71	.098	40.51	.098	40.32	.098	40.13	.098	39.94	.098	39.75	.097	39.57	.097	39.40	.097	39.23	.096	39.07	.096
1340	42.29	.096	42.07	.097	41.85	.097	41.64	.097	41.43	.097	41.23	.096	41.04	.096	40.85	.096	40.66	.096	40.48	.096	40.30	.096	40.13	.095	39.96	.095
1350	43.21	.095	42.99	.095	42.77	.095	42.55	.095	42.34	.095	42.14	.095	41.94	.095	41.74	.095	41.55	.095	41.37	.095	41.19	.095	41.01	.094	40.84	.094
1360	44.12	.094	43.89	.094	43.66	.093	43.44	.093	43.23	.093	43.02	.093	42.82	.093	42.62	.093	42.42	.093	42.23	.093	42.05	.093	41.87	.092	41.69	.092
1370	45.01	.092	44.78	.092	44.55	.092	44.32	.092	44.10	.092	43.89	.092	43.68	.092	43.48	.092	43.28	.092	43.09	.092	42.90	.092	42.72	.091	42.54	.091
1380	45.89	.091	45.65	.091	45.41	.091	45.18	.091	44.96	.091	44.75	.091	44.54	.091	44.33	.091	44.13	.091	43.93	.091	43.74	.091	43.55	.090	43.37	.090
1390	46.76	.089	46.52	.089	46.28	.089	46.05	.089	45.82	.089	45.60	.089	45.28	.089	45.17	.089	44.97	.089	44.77	.089	44.58	.089	44.39	.089	44.20	.089
1400	47.63	.088	47.38	.088	47.13	.088	46.89	.088	46.66	.088	46.44	.088	46.22	.088	46.00	.088	45.79	.088	45.59	.088	45.39	.088	45.20	.087	45.01	.087
1410	48.46	.086	48.21	.086	47.96	.086	47.72	.086	47.49	.086	47.26	.086	47.04	.086	46.82	.086	46.60	.086	46.39	.086	46.19	.086	45.99	.086	45.80	.086
1420	49.28	.084	49.03	.084	48.78	.084	48.53	.084	48.29	.084	48.06	.084	47.83	.084	47.61	.084	47.39	.084	47.18	.084	46.98	.084	46.78	.084	46.58	.084
1430	50.12	.083	49.86	.083	49.60	.083	49.35	.083	49.11	.083	48.87	.083	48.64	.083	48.41	.083	48.19	.083	47.97	.083	47.76	.083	47.56	.083	47.36	.083
1440	50.92	.082	50.66	.082	50.40	.082	50.14	.082	49.89	.082	49.65	.082	49.42	.082	49.19	.082	48.96	.082	48.74	.082	48.53	.082	48.32	.082	48.12	.082
1450	51.72	.080	51.45	.080	51.18	.080	50.92	.080	50.67	.080	50.43	.080	50.19	.080	49.96	.080	49.73	.080	49.51	.080	49.29	.080	49.08	.080	48.87	.080
1460	52.50	.079	52.23	.079	51.96	.079	51.70	.079	51.45	.079	51.20	.079	50.96	.079	50.72	.079	50.49	.079	50.26	.079	50.04	.079	49.83	.079	49.62	.079
1470	53.29	.078	53.01	.078	52.74	.078	52.47	.078	52.21	.078	51.96	.078	51.71	.078	51.47	.078	51.24	.078	51.01	.078	50.79	.078	50.57	.078	50.36	.078
1480	54.05	.077	53.76	.077	53.48	.077	53.21	.077	52.95	.077	52.69	.077	52.44	.077	52.20	.077	51.96	.077	51.73	.077	51.51	.077	51.29	.077	51.07	.077
1490	54.81	.076	54.52	.076	54.24	.076	53.97	.076	53.70	.076	53.44	.076	53.19	.076	52 94	.076	52.70	.076	52.46	.076	52.23	.076	52.01	.076	51.79	.076
1500	55.56	.075	55.26	.075	54.98	.075	54.70	.075	54.43	.075	54.17	.075	53 92	.075	53.67	.075	53.42	.075	53.18	.075	52.95	.075	52.72	.075	52.50	.075

[10]Stevens, A Diagram for the Determination of the Solution Ratios of Slimes and Calculations Made Therefrom—Mex. Min Journ., Vol. 105, pp. 24, 25.

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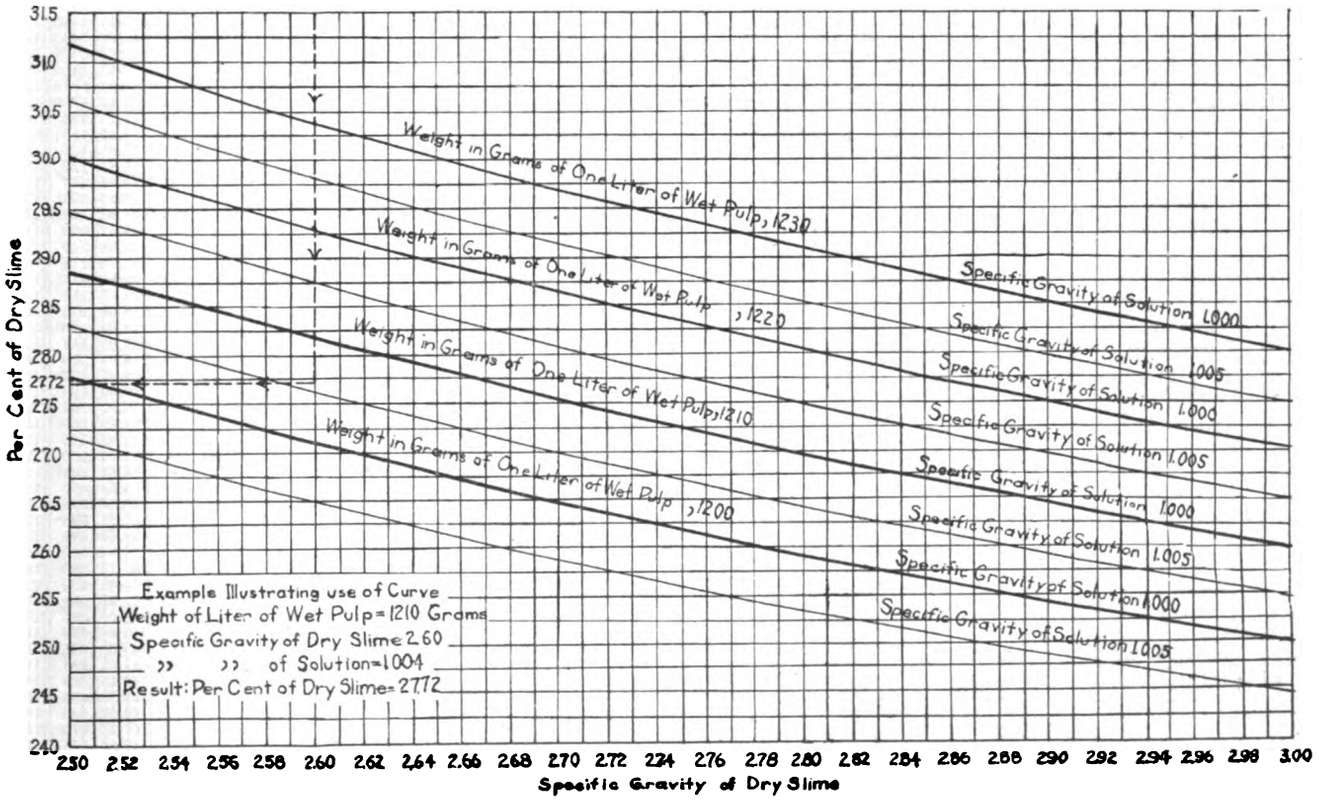
TABLE IA. LOGARITHMS OF PER CENT. OF DRY SLIME AND CORRECTION FOR SPECIFIC GRAVITY OF SOLUTION

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp	2.50	Correction	2.52	Correction	2.54	Correction	2.56	Correction	2.58	Correction	2.60	Correction	2.62	Correction	2.64	Correction	2.66	Correction	2.68	Correction	2.70	Correction	2.72	Correction	2.74	Correction
1010	.2175	.1650	2154	.1642	.2130	.1633	.2109	.1625	.2087	.1617	.2066	.1609	.2044	.1601	.2025	.1594	.2003	.1586	.1984	.1579	.1967	.1573	.1948	.1566	.1931	.1560
1020	.5143	.1623	5120	.1615	.5097	.1607	.5075	.1598	.5053	.1590	.5032	.1583	.5012	.1575	.4991	.1568	.4972	.1561	.4953	.1555	.4935	.1548	.4915	.1541	.4897	.1535
1030	.6861	.1597	6839	.1589	.6816	.1581	.6794	.1573	.6772	.1565	.6751	.1558	.6731	.1551	.6711	.1544	.6691	.1537	.6672	.1531	.6653	.1525	.6634	.1518	.6616	.1512
1040	.8069	.1571	8047	.1564	.8024	.1556	.8002	.1548	.7980	.1541	.7960	.1534	.7939	.1527	.7918	.1520	.7898	.1513	.7879	.1507	.7860	.1501	.7842	.1495	.7824	.1489
1050	.8996	.1545	.8974	.1537	.8951	.1530	.8929	.1523	.8908	.1516	.8887	.1509	.8866	.1502	.8846	.1496	.8826	.1490	.8806	.1484	.8788	.1478	.8769	.1472	.8751	.1466
1060	.9747	.1521	.9725	.1514	.9702	.1506	.9680	.1499	.9659	.1492	.9638	.1486	.9617	.1479	.9597	.1473	.9577	.1467	.9557	.1461	.9539	.1455	.9520	.1449	.9502	.1443
1070	.0374	.149	0354	.149	.0330	.148	0306	.147	.0286	.146	.0265	.146	.0245	.145	.0224	.145	.0204	.144	.0187	.144	.0166	.143	.0149	.143	.0128	.142
1080	.0913	.147	0892	.146	.0871	.146	.0849	.145	.0828	.145	.0806	.144	.0785	.143	.0763	.142	.0745	.142	.0726	.142	.0708	.141	.0689	.141	.0671	.140
1090	.1386	.145	1364	.144	.1342	.144	.1319	.143	.1297	.142	.1278	.142	.1255	.140	.1235	.140	.1216	.140	.1196	.139	.1179	.139	.1159	.138	.1143	.138
1100	.1804	.143	1781	.142	.1758	.141	.1735	.140	.1714	.140	.1694	.139	.1673	.139	.1652	.138	.1632	.137	.1614	.137	.1596	.137	.1578	.137	.1559	.136
1110	.2180	.140	2156	.139	.2133	.138	.2111	.138	.2090	.138	.2071	.138	.2049	.137	.2028	.136	.2009	.136	.1989	.135	.1970	.135	.1951	.134	.1934	.134
1120	.2519	.138	.2494	.137	.2472	.137	2450	.136	.2430	.136	.2408	.135	.2388	.135	.2368	.134	.2348	.134	.2327	.133	.2310	.133	.2292	.133	.2274	.132
1130	.2826	.135	2804	.135	.2781	.134	.2758	.133	.2737	.133	.2716	.132	.2695	.132	.2676	.132	.2655	.131	.2636	.131	.2617	.130	.2598	.130	.2582	.130
1140	.3111	.134	3088	.133	.3064	.132	.3043	.132	.3021	.131	.2999	.130	.2980	.130	.2960	.130	.2940	.130	.2920	.129	.2903	.129	.2882	.128	.2865	.128
1150	.3373	.132	3349	.131	.3326	.130	3304	.130	.3284	.130	.3263	.130	.3243	.129	.3222	.129	.3201	.128	.3183	.128	.3164	.127	.3145	.127	.3126	.126
1160	.3615	.130	3593	.129	.3570	.129	3547	.128	.3526	.127	.3504	.127	.3483	.126	.3464	.126	.3444	.126	.3424	.125	.3406	.125	.3387	.124	.3369	.124
1170	.3840	.127	3817	.126	.3795	.126	.3773	.126	.3751	.125	.3731	.125	.3711	.125	.3690	.124	.3670	.124	.3651	.124	.3632	.123	.3614	.123	.3595	.122
1180	.4052	.125	.4030	.125	.4007	.125	.3985	.124	.3964	.124	.3943	.123	.3922	.123	.3902	.123	.3883	.123	.3863	.122	.3844	.122	.3824	.121	.3806	.120
1190	.4250	.123	4228	.123	.4206	.123	.4185	.122	.4163	.122	.4141	.121	.4121	.121	.4101	.121	.4081	.120	.4062	.120	.4043	.120	.4024	.119	.4005	.118
1200	.4436	.121	4414	.121	.4392	.121	.4370	.120	.4347	.119	.4326	.119	.4306	.118	.4286	.118	.4267	.118	.4247	.118	.4228	.117	.4209	.117	.4191	.117
1210	.4612	.119	4589	.119	.4567	.119	.4545	.118	.4524	.118	.4502	.117	.4482	.117	.4462	.117	.4442	.117	.4423	.117	.4404	.116	4385	.116	.4366	.115
1220	.4778	.118	4755	.117	.4733	.117	.4711	.116	.4689	.116	.4669	.116	.4648	.115	.4628	.115	.4608	.114	.4588	.114	.4570	.114	.4551	.114	.4533	.114
1230	.4936	.115	4914	.115	.4891	.115	.4869	.114	.4847	.114	.4827	.114	.4806	.113	.4786	.113	.4766	.113	.4747	.113	.4729	.112	.4709	.112	.4690	.111
1240	.5087	.114	5064	.114	.5041	.113	.5019	.113	.4997	.112	.4976	.112	.4955	.112	.4936	.112	.4916	.112	.4897	.112	.4878	.112	.4860	.111	.4842	.111
1250	.5228	.112	5206	.112	.5184	.112	.5161	.111	.5140	.111	.5119	.110	.5099	.110	.5079	.110	.5058	.110	.5038	.109	.5019	.109	.5001	.109	.4983	.109
1260	.5364	.111	5342	.111	.5319	.110	.5297	.110	.5275	.109	.5254	.109	.5234	.109	.5214	.109	.5194	.109	.5175	.109	.5156	.108	.5138	.108	.5119	.108
1270	.5494	.108	5472	.108	.5449	.108	.5427	.108	.5406	.108	.5384	.108	.5364	.107	.5344	.107	.5324	.106	.5305	.106	.5285	.106	.5266	.106	.5248	.105
1280	.5618	.107	5595	.107	.5573	.106	.5551	.106	.5529	.106	.5508	.105	.5488	.105	.5468	.105	.5448	.105	.5428	.105	.5410	.105	.5391	.104	.5372	.104
1290	.5736	.104	5714	.104	.5691	.104	.5669	.104	.5648	.104	.5626	.104	.5606	.103	.5586	.103	.5566	.103	.5546	.103	.5528	.103	.5510	.102	.5491	.102
1300	.5850	.103	5827	.103	.5805	.102	.5783	.102	.5761	.102	.5740	.102	.5719	.102	.5700	.102	.5680	.102	.5661	.102	.5642	.102	.5623	.101	.5604	.101
1310	.5959	.102	5936	.102	.5914	.101	.5892	.101	.5870	.101	.5849	.101	.5829	.101	.5808	.101	.5789	.100	.5769	.100	.5751	.100	.5732	.100	.5714	.100
1320	.6064	.100	6041	.100	.6018	.099	.5997	.099	.5975	.099	.5954	.098	.5933	.098	.5913	.098	.5893	.098	.5874	.098	.5855	.098	.5835	.097	.5817	.097
1330	.6164	.098	6142	.098	.6119	.098	6097	.098	.6076	.098	.6055	.098	.6035	.098	.6014	.098	.5993	.097	.5974	.097	.5955	.097	.5936	.096	.5918	.096
1340	.6262	.098	6240	.098	.6217	.097	6195	.097	.6173	.097	.6152	.096	.6132	.096	.6112	.096	.6092	.096	.6072	.096	.6053	.096	.6035	.095	.6016	.095
1350	.6356	.095	6334	.095	.6311	.095	6289	.095	.6268	.095	.6247	.095	.6226	.095	.6206	.095	.6186	.095	.6167	.095	.6148	.095	.6129	.094	.6111	.094
1360	.6446	.094	6424	.094	.6401	.094	.6379	.093	.6358	.093	.6337	.093	.6316	.093	.6296	.093	.6276	.093	.6256	.093	.6238	.093	.6219	.092	.6200	.092
1370	.6533	.092	6511	.092	.6488	.092	.6466	.092	.6444	.092	.6424	.092	.6403	.092	.6383	.092	.6363	.092	.6344	.092	.6325	.092	.6306	.091	.6288	.091
1380	.6617	.091	6594	.091	.6572	.091	.6549	.091	.6528	.091	.6508	.091	.6488	.091	.6467	.091	.6447	.091	.6428	.091	.6409	.091	.6390	.091	.6372	.091
1390	.6699	.089	6676	.089	.6654	.089	.6632	.089	.6611	.089	.6590	.089	.6569	.089	.6548	.089	.6529	.089	.6510	.089	.6491	.089	.6473	.089	.6454	.089
1400	.6779	.089	6756	.089	.6733	.088	.6711	.088	.6689	.088	.6669	.088	.6648	.088	.6628	.088	.6608	.088	.6589	.088	.6570	.088	.6551	.087	.6533	.087
1410	.6854	.086	.6831	.086	.6809	.086	.6787	.086	.6766	.086	.6745	.086	.6725	.086	.6704	.086	.6684	.086	.6664	.086	.6645	.086	.6627	.086	.6609	.086
1420	.6927	.084	6905	.084	.6882	.084	.6860	.084	.6839	.084	.6818	.084	.6797	.084	.6777	.084	.6757	.084	.6738	.084	.6719	.084	.6701	.084	.6682	.084
1430	.7000	.084	6978	.084	.6955	.084	.6933	.084	.6912	.084	.6890	.084	.6870	.084	.6849	.084	.6830	.084	.6810	.084	.6791	.084	.6772	.084	.6754	.084
1440	.7069	.082	7047	.082	.7024	.082	7002	082	.6980	.082	6959	.082	.6939	.082	.6919	.082	.6898	.082	.6879	.082	.6860	.082	.6841	.082	.6823	.082
1450	.7137	.081	7114	.081	.7091	.080	7069	.080	.7048	.080	.7027	.080	.7006	.080	.6986	.080	.6966	.080	.6947	.080	.6928	.080	.6909	.080	.6890	.080
1460	.7202	.080	7179	.080	.7157	.080	7135	.080	.7114	.080	.7093	.080	.7072	.080	.7052	.080	.7032	.080	.7012	.080	.6993	.080	.6975	.080	.6957	.080
1470	.7266	.078	.7244	.078	.7221	.078	7199	.078	.7177	.078	.7157	.078	.7136	.078	.7116	.078	.7096	.078	.7077	.078	.7058	.078	.7039	.078	.7021	.078
1480	.7327	.077	7305	.077	.7282	.077	7260	.077	.7239	.077	.7217	.077	.7197	.077	.7177	.077	.7157	.077	.7137	.077	.7119	.077	.7100	.077	.7082	.077
1490	.7388	.076	.7366	.076	.7343	.076	.7321	.077	.7300	.077	.7279	.077	.7258	.077	.7238	.077	.7218	.077	.7198	.077	.7179	.077	.7161	.077	.7142	.077
1500	.7447	.075	.7424	.075	.7402	.075	.7380	.075	.7358	.075	.7338	.075	.7317	.076	.7297	.076	.7277	.076	.7257	.076	.7239	.076	.7220	.076	.7202	.076

Note—The natural values are given for the corrections on account of the manner in which they are applied.



Curve IB. Per Cent of Dry Slime and Correction for Sp. Gr. of Solution

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As the plus and minus errors in the tables are approximately evenly distributed and the total area in either direction is about the same it is evident that if a particular table is used for calculating the tonnage of a number of slime charges, several different values occuring in this table will be brought into use. The error introduced through this source would, therefore, be largely compensating as regards the total monthly or yearly tonnage of a slime plant. In any event, the error introduced through the use of the tables would be much less than the inherent error in the methods of ascertaining certain of the data used in applying the tables. With individual charges, when extreme accuracy is desired, the results can be calculated by the more accurate methods previously mentioned, but it must be borne in mind that if any benefit is to be derived through greater refinement in making the computations, the same degree of accuracy must be maintained in ascertaining the data upon which these computations are based.

The following formula[12], with the exception of Hyder's work, has generally heretofore formed the basis of the computations for the constants of slime pulps:

$$P = \frac{100\,S\,(a-1)}{a\,(S-1)}$$

[12]"The Cyanide Handbook," J. E. Clennell, New York, 1910, pp. 479-480.

P = Percentage of dry slime in wet pulp;
S = Specific gravity of dry slime;
a = Specific gravity of wet pulp;
1 = Specific gravity of solution.

It will be noted that in this formula the specific gravity of the solution is taken as 1, while in reality it is always somewhat greater than 1. Mr. Turner has investigated the specific gravity of a number of cyanide-mill solutions. Some of the results are given in the accompanying table:

SPECIFIC GRAVITY OF WORKING CYANIDE SOLUTIONS

Solution		Specific Gravity
Fresh solution	.....	1.00170
Butters plant, Virginia City, Nev	Heads	1.00281
Butters plant, Virginia City, Nev	Tails	1.00279
Belmont plant, Tonopah, Nev	Heads	1.00881
Belmont plant, Tonopah, Nev	Tails	1.00873
Montana-Tonopah, Tonopah, Nev	Heads	1.00314
Empire, Grass Valley, Calif	Heads	1.00142
[13]Portland, Colorado Springs, Colo	Heads	1.01000
[14]South Africa, average	.....	1.00210
Pittsburgh-Silver Peak, Blair, Nev	Heads	1.00309

We have derived the above formula, assigning a general value d for the specific gravity of the solution. The principal steps in the derivation are given below.

Let
a = Specific gravity of wet pulp;
S = Specific gravity of dry slime;
V = Total volume of wet pulp;
m = Total weight of dry slime in wet pulp;
c = Volume of solution in wet pulp;
d = Specific gravity of solution;
P = Percentage of dry slime in wet pulp;

TABLE 1. PER CENT. OF DRY SLIME AND CORRECTION FOR SPECIFIC GRAVITY OF SOLUTION—Cont.

Formula: $P = \frac{100\,S\,(a-d)}{a\,(S-d)}$

Specific Gravity of Dry Slime

2.76	Correction	2.78	Correction	2.80	Correction	2.82	Correction	2.84	Correction	2.86	Correction	2.88	Correction	2.90	Correction	2.92	Correction	2.94	Correction	2.96	Correction	2.98	Correction	3.00	Correction	
1.553	.1553	1.546	.1546	1.540	.1540	1.534	.1534	1.528	.1528	1.523	.1523	1.517	.1517	1.511	.1511	1.506	.1506	1.500	.1500	1.495	.1495	1.490	.1490	1.485	.1485	1010
3.075	.1529	3.062	.1522	3.050	.1516	3.038	.1510	3.026	.1505	3.015	.1499	3.003	.1493	2.992	.1488	2.982	.1483	2.971	.1478	2.961	.1473	2.951	.1468	2.941	.1463	1020
4.568	.1505	4.549	.1499	4.531	.1494	4.513	.1488	4.496	.1483	4.479	.1477	4.462	.1471	4.446	.1466	4.430	.1461	4.414	.1456	4.398	.1451	4.383	.1446	4.369	.1442	1030
6.033	.1483	6.008	.1477	5.984	.1472	5.960	.1466	5.937	.1460	5.915	.1455	5.893	.1450	5.871	.1445	5.850	.1440	5.829	.1435	5.809	.1430	5.789	.1426	5.770	.1422	1040
7.468	.1460	7.437	.1454	7.408	.1448	7.378	.1443	7.350	.1438	7.323	.1433	7.295	.1427	7.268	.1422	7.243	.1418	7.216	.1413	7.191	.1408	7.166	.1404	7.143	.1400	1050
8.878	.1437	8.841	.1432	8.806	.1427	8.771	.1423	8.738	.1418	8.705	.1412	8.672	.1406	8.640	.1401	8.610	.1397	8.578	.1393	8.549	.1388	8.519	.1384	8.491	.1380	1060
10.26	.142	10.22	.141	10.18	.141	10.14	.140	10.10	.140	10.06	.139	10.02	.138	9.984	.1380	9.948	.1375	9.913	.1371	9.879	.1367	9.845	.1363	9.812	.1360	1070
11.62	.140	11.57	.139	11.52	.138	11.48	.138	11.44	.138	11.39	.138	11.35	.137	11.31	.137	11.27	.136	11.23	.136	11.19	.135	11.15	.135	11.11	.134	1080
12.95	.137	12.90	.137	12.84	.136	12.79	.136	12.74	.135	12.70	.135	12.65	.134	12.60	.134	12.55	.133	12.51	.133	12.47	.133	12.43	.133	12.39	.133	1090
14.26	.136	14.20	.135	14.14	.134	14.08	.134	14.03	.134	13.98	.133	13.93	.133	13.88	.133	13.83	.132	13.78	.132	13.73	.131	13.68	.131	13.63	.130	1100
15.54	.133	15.48	.133	15.42	.133	15.36	.133	15.30	.132	15.24	.131	15.18	.130	15.12	.130	15.07	.130	15.02	.130	14.97	.129	14.92	.129	14.87	.129	1110
16.80	.131	16.73	.131	16.67	.131	16.60	.130	16.54	.130	16.48	.129	16.41	.128	16.35	.128	16.30	.128	16.24	.128	16.18	.127	16.13	.127	16.08	.127	1120
18.04	.129	17.96	.128	17.89	.128	17.82	.128	17.75	.127	17.69	.127	17.62	.126	17.56	.126	17.49	.126	17.43	.125	17.37	.125	17.31	.125	17.25	.124	1130
19.26	.128	19.18	.127	19.10	.126	19.02	.126	18.95	.126	18.88	.125	18.81	.125	18.74	.125	18.68	.125	18.61	.124	18.54	.123	18.48	.123	18.42	.123	1140
20.45	.125	20.37	.125	20.29	.125	20.21	.125	20.13	.124	20.06	.124	19.98	.123	19.91	.123	19.84	.123	19.77	.123	19.70	.122	19.63	.122	19.57	.122	1150
21.63	.124	21.54	.123	21.45	.123	21.37	.123	21.29	.123	21.21	.122	21.13	.121	21.05	.121	20.97	.120	20.90	.120	20.83	.120	20.75	.119	20.68	.119	1160
22.78	.121	22.69	.121	22.60	.121	22.51	.121	22.42	.121	22.34	.120	22.25	.119	22.17	.119	22.10	.119	22.02	.119	21.94	.118	21.86	.118	21.79	.118	1170
23.92	.120	23.82	.120	23.73	.120	23.64	.120	23.55	.119	23.46	.119	23.37	.118	23.28	.118	23.20	.118	23.12	.118	23.04	.117	22.96	.117	22.88	.117	1180
25.04	.118	24.94	.118	24.84	.118	24.74	.117	24.65	.117	24.55	.117	24.46	.116	24.37	.116	24.29	.116	24.20	.116	24.11	.115	24.03	.115	23.95	.115	1190
26.14	.117	26.03	.116	25.92	.115	25.82	.115	25.72	.115	25.63	.115	25.53	.115	25.44	.115	25.34	.114	25.25	.113	25.16	.113	25.08	.113	25.00	.113	1200
27.21	.115	27.10	.114	26.99	.114	26.89	.114	26.79	.114	26.69	.113	26.59	.113	26.49	.113	26.39	.112	26.30	.112	26.21	.112	26.12	.112	26.03	.112	1210
28.28	.113	28.16	.113	28.05	.113	27.94	.113	27.83	.112	27.72	.111	27.62	.111	27.52	.111	27.42	.111	27.32	.111	27.23	.111	27.14	.111	27.05	.111	1220
29.32	.111	29.20	.111	29.09	.111	28.97	.111	28.86	.111	28.75	.110	28.64	.109	28.54	.109	28.44	.109	28.34	.109	28.24	.109	28.14	.109	28.05	.109	1230
30.36	.110	30.23	.110	30.11	.110	29.99	.110	29.87	.109	29.76	.109	29.65	.108	29.54	.108	29.43	.107	29.33	.107	29.23	.107	29.13	.107	29.03	.107	1240
31.37	.109	31.24	.109	31.11	.108	30.99	.108	30.87	.108	30.75	.107	30.63	.106	30.52	.106	30.41	.106	30.30	.106	30.20	.106	30.10	.106	30.00	.106	1250
32.36	.108	32.23	.107	32.10	.107	31.97	.107	31.85	.107	31.73	.106	31.61	.105	31.49	.105	31.38	.105	31.27	.105	31.16	.105	31.05	.104	30.95	.104	1260
33.34	.105	33.20	.105	33.07	.105	32.94	.105	32.81	.105	32.69	.104	32.57	.104	32.45	.104	32.33	.104	32.22	.104	32.11	.104	32.00	.103	31.89	.103	1270
34.31	.104	34.17	.103	34.03	.103	33.89	.103	33.76	.103	33.63	.102	33.51	.102	33.39	.102	33.27	.102	33.15	.102	33.04	.102	32.93	.102	32.82	.102	1280
35.26	.102	35.11	.102	34.97	.102	34.83	.102	34.70	.101	34.57	.101	34.44	.101	34.31	.101	34.19	.100	34.07	.100	33.95	.100	33.83	.100	33.72	.100	1290
36.19	.101	36.04	.100	35.90	.100	35.76	.100	35.62	.099	35.48	.099	35.35	.099	35.22	.099	35.09	.098	34.97	.098	34.85	.098	34.73	.098	34.62	.098	1300
37.11	.100	36.96	.099	36.81	.099	36.67	.099	36.53	.098	36.39	.098	36.25	.098	36.12	.098	35.99	.097	35.80	.097	35.74	.097	35.62	.097	35.50	.097	1310
38.01	.097	37.85	.097	37.70	.097	37.55	.097	37.41	.097	37.27	.096	37.13	.096	36.99	.096	36.86	.096	36.73	.096	36.60	.096	36.48	.096	36.36	.096	1320
38.91	.096	38.75	.096	38.59	.096	38.44	.096	38.29	.096	38.15	.095	38.01	.095	37.87	.095	37.73	.095	37.59	.095	37.46	.095	37.33	.095	37.21	.095	1330
39.79	.095	39.63	.095	39.47	.095	39.31	.095	39.16	.094	39.01	.094	38.87	.094	38.73	.094	38.59	.094	38.45	.094	38.32	.094	38.19	.094	38.06	.094	1340
40.67	.094	40.50	.094	40.34	.094	40.18	.094	40.02	.093	39.87	.093	39.72	.093	39.57	.093	39.43	.093	39.29	.093	39.16	.093	39.03	.093	38.90	.093	1350
41.51	.092	41.34	.092	41.18	.092	41.02	.092	40.86	.092	40.71	.092	40.56	.092	40.41	.091	40.26	.091	40.12	.091	39.98	.091	39.84	.091	39.71	.091	1360
42.36	.091	42.18	.091	42.01	.091	41.84	.091	41.68	.090	41.52	.090	41.37	.090	41.22	.090	41.07	.090	40.93	.090	40.79	.090	40.65	.090	40.51	.090	1370
43.19	.090	43.01	.089	42.83	.089	42.66	.089	42.50	.089	42.34	.089	42.18	.089	42.03	.089	41.88	.089	41.73	.089	41.58	.089	41.44	.089	41.30	.089	1380
44.01	.089	43.83	.088	43.65	.088	43.48	.088	43.31	.088	43.15	.088	42.99	.088	42.83	.087	42.67	.087	42.52	.087	42.37	.087	42.23	.087	42.09	.087	1390
44.82	.087	44.63	.087	44.45	.087	44.27	.087	44.10	.087	43.93	.087	43.77	.086	43.61	.086	43.45	.086	43.30	.086	43.15	.086	43.00	.086	42.86	.086	1400
45.61	.086	45.42	.086	45.24	.086	45.06	.086	44.89	.086	44.72	.086	44.55	.085	44.38	.085	44.22	.085	44.06	.085	43.91	.085	43.76	.085	43.62	.085	1410
46.38	.084	46.19	.084	46.00	.084	45.82	.084	45.64	.084	45.47	.085	45.30	.084	45.14	.084	44.97	.084	44.81	.084	44.66	.084	44.51	.084	44.36	.084	1420
47.16	.083	46.97	.083	46.78	.083	46.59	.083	46.41	.083	46.24	.083	46.07	.083	45.90	.083	45.74	.083	45.58	.083	45.42	.083	45.26	.083	45.11	.083	1430
47.92	.082	47.72	.082	47.53	.082	47.34	.082	47.16	.082	46.98	.082	46.81	.082	46.64	.082	46.47	.082	46.30	.082	46.14	.082	45.98	.082	45.83	.082	1440
48.66	.080	48.46	.080	48.26	.080	48.08	.080	47.90	.080	47.72	.080	47.54	.080	47.36	.080	47.19	.080	47.02	.080	46.86	.080	46.70	.080	46.55	.080	1450
49.41	.079	49.21	.079	49.01	.079	48.82	.079	48.63	.079	48.45	.079	48.27	.079	48.09	.079	47.91	.079	47.74	.079	47.57	.079	47.41	.079	47.26	.079	1460
50.15	.078	49.94	.078	49.74	.078	49.54	.078	49.35	.078	49.16	.078	48.98	.078	48.80	.078	48.62	.078	48.45	.078	48.28	.078	48.12	.078	47.96	.078	1470
50.85	.077	50.64	.077	50.45	.077	50.24	.077	50.05	.077	49.86	.077	49.68	.077	49.50	.077	49.32	.077	49.14	.077	48.97	.077	48.80	.077	48.64	.077	1480
51.57	.076	51.36	.076	51.16	.076	50.95	.076	50.76	.076	50.57	.076	50.38	.076	50.19	.076	50.01	.076	49.83	.076	49.66	.076	49.49	.076	49.33	.076	1490
52.28	.075	52.06	.075	51.85	.075	51.65	.075	51.45	.075	51.26	.075	51.07	.075	50.88	.075	50.69	.075	50.51	.075	50.34	.075	50.17	.075	50.00	.075	1500

Weight in Grams of One Liter of Wet Pulp

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TABLE IA. LOGARITHMS OF PER CENT. OF DRY SLIME AND CORRECTION FOR SPECIFIC GRAVITY OF SOLUTION—Cont.

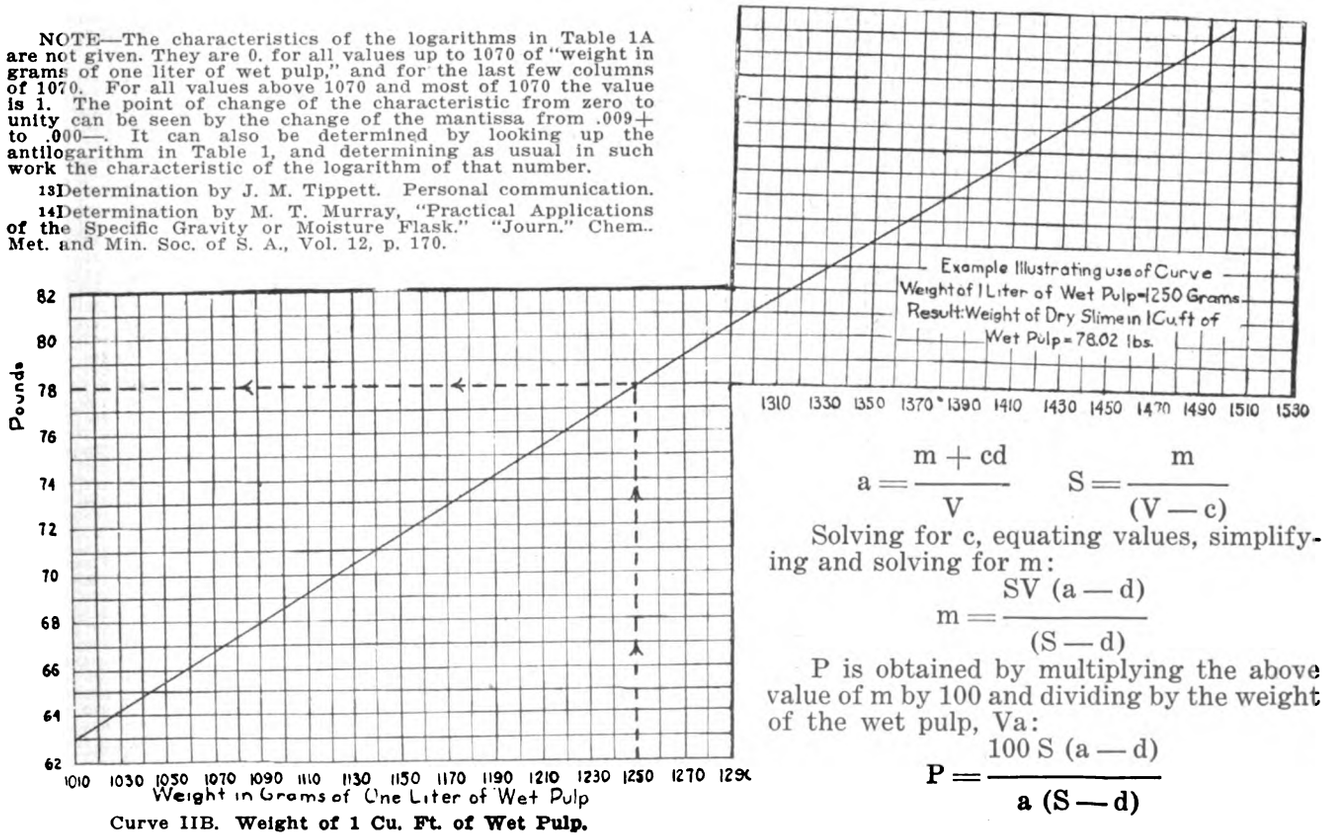
Specific Gravity of Dry Slime

2.76	Correction	2.78	Correction	2.80	Correction	2.82	Correction	2.84	Correction	2.86	Correction	2.88	Correction	2.90	Correction	2.92	Correction	2.94	Correction	2.96	Correction	2.98	Correction	3.00	Correction	Weight in Grams of One Liter of Wet Pulp
.1912	.1553	.1892	.1546	.1875	.1540	.1858	.1534	.1841	.1528	.1827	.1523	.1810	.1517	.1793	.1511	.1778	.1506	.1761	.1500	.1746	.1495	.1732	.1490	.1717	.1485	1010
.4878	.1529	.4860	.1522	.4843	.1516	.4826	.1510	.4809	.1505	.4793	.1499	.4776	.1493	.4760	.1488	.4745	.1483	.4729	.1478	.4714	.1473	.4700	.1468	.4685	.1463	1020
.6597	.1505	.6579	.1499	.6562	.1494	.6545	.1488	.6528	.1483	.6512	.1477	.6495	.1471	.6480	.1466	.6464	.1461	.6448	.1456	.6433	.1451	.6418	.1446	.6404	.1442	1030
.7805	.1483	.7787	.1477	.7770	.1472	.7752	.1466	.7736	.1460	.7720	.1455	.7703	.1450	.7687	.1445	.7672	.1440	.7656	.1435	.7641	.1430	.7626	.1426	.7612	.1422	1040
.8732	.1460	.8714	.1454	.8697	.1448	.8679	.1443	.8663	.1438	.8647	.1433	.8630	.1427	.8614	.1422	.8599	.1413	.8583	.1413	.8568	.1408	.8553	.1404	.8539	.1400	1050
.9483	.1437	.9465	.1432	.9448	.1427	.9430	.1423	.9414	.1418	.9398	.1412	.9381	.1406	.9365	.1401	.9350	.1397	.9334	.1393	.9319	.1388	.9304	.1384	.9290	.1380	1060
.0111	.142	.0094	.141	.0077	.141	.0060	.140	.0043	.140	.0026	.139	.0009	.138	.9993	.1380	.9977	.1375	.9962	.1371	.9947	.1367	.9932	.1363	.9918	.1360	1070
.0652	.140	.0633	.139	.0615	.138	.0599	.138	.0584	.138	.0565	.138	.0549	.137	.0535	.137	.0519	.136	.0504	.136	.0488	.135	.0473	.135	.0457	.134	1080
.1123	.137	.1106	.137	.1086	.136	.1069	.136	.1052	.135	.1038	.135	.1021	.134	.1004	.134	.0987	.133	.0973	.133	.0959	.133	.0945	.133	.0931	.133	1090
.1541	.136	.1523	.135	.1504	.134	.1486	.134	.1471	.134	.1455	.133	.1439	.133	.1424	.133	.1408	.132	.1392	.132	.1377	.131	.1361	.131	.1345	.130	1100
.1915	.133	.1898	.133	.1881	.133	.1864	.133	.1847	.132	.1830	.131	.1813	.130	.1796	.130	.1781	.130	.1767	.130	.1752	.129	.1738	.129	.1723	.129	1110
.2253	.131	.2235	.131	.2219	.131	.2201	.130	.2185	.130	.2170	.129	.2151	.128	.2135	.128	.2122	.128	.2106	.128	.2090	.127	.2076	.127	.2063	.127	1120
.2562	.129	.2543	.128	.2526	.128	.2509	.128	.2492	.127	.2477	.127	.2460	.126	.2445	.126	.2428	.125	.2413	.125	.2398	.125	.2383	.125	.2368	.124	1130
.2847	.128	.2828	.127	.2810	.126	.2792	.126	.2776	.126	.2760	.125	.2744	.125	.2728	.125	.2714	.125	.2697	.124	.2681	.123	.2667	.123	.2653	.123	1140
.3107	.125	.3090	.125	.3073	.125	.3056	.125	.3038	.124	.3023	.124	.3006	.123	.2991	.123	.2975	.123	.2960	.123	.2945	.122	.2929	.122	.2915	.122	1150
.3351	.124	.3332	.123	.3314	.123	.3298	.123	.3282	.123	.3265	.122	.3249	.121	.3233	.121	.3216	.120	.3201	.120	.3187	.120	.3170	.119	.3156	.119	1160
.3576	.121	.3558	.121	.3541	.121	.3524	.121	.3506	.120	.3491	.120	.3473	.119	.3458	.119	.3444	.119	.3428	.119	.3412	.118	.3397	.118	.3383	.118	1170
.3788	.120	.3769	.120	.3753	.120	.3736	.120	.3720	.120	.3703	.119	.3687	.118	.3670	.118	.3655	.118	.3640	.118	.3625	.117	.3610	.117	.3595	.117	1180
.3986	.118	.3969	.118	.3952	.118	.3934	.117	.3918	.117	.3901	.116	.3885	.116	.3869	.116	.3854	.116	.3838	.116	.3822	.115	.3808	.115	.3793	.115	1190
.4173	.117	.4155	.116	.4136	.115	.4120	.115	.4103	.115	.4087	.115	.4071	.115	.4055	.115	.4038	.114	.4023	.113	.4007	.113	.3993	.113	.3979	.113	1200
.4347	.114	.4330	.114	.4312	.114	.4296	.114	.4280	.114	.4263	.114	.4247	.113	.4231	.113	.4214	.112	.4200	.112	.4185	.112	.4170	.112	.4155	.112	1210
.4515	.113	.4496	.113	.4479	.113	.4462	.113	.4445	.112	.4428	.111	.4412	.111	.4396	.111	.4381	.111	.4365	.111	.4350	.111	.4336	.111	.4322	.111	1220
.4672	.111	.4654	.111	.4637	.111	.4619	.111	.4603	.111	.4586	.110	.4570	.109	.4554	.109	.4539	.109	.4524	.109	.4509	.109	.4493	.109	.4479	.109	1230
.4823	.111	.4804	.110	.4787	.110	.4770	.110	.4752	.109	.4736	.109	.4720	.108	.4704	.108	.4688	.107	.4673	.107	.4658	.107	.4643	.107	.4629	.107	1240
.4965	.109	.4947	.109	.4929	.108	.4912	.108	.4895	.108	.4878	.107	.4861	.106	.4846	.106	.4830	.106	.4814	.106	.4800	.106	.4780	.106	.4771	.106	1250
.5100	.108	.5083	.108	.5065	.108	.5047	.107	.5031	.107	.5015	.106	.4998	.106	.4982	.105	.4967	.105	.4951	.105	.4936	.105	.4921	.104	.4907	.104	1260
.5230	.105	.5211	.105	.5194	.105	.5177	.105	.5160	.105	.5144	.104	.5128	.104	.5112	.104	.5096	.104	.5081	.104	.5066	.104	.5051	.103	.5036	.103	1270
.5354	.104	.5336	.103	.5319	.103	.5301	.103	.5284	.103	.5267	.102	.5252	.102	.5236	.102	.5220	.102	.5205	.102	.5190	.102	.5176	.102	.5161	.102	1280
.5473	.102	.5454	.102	.5437	.102	.5420	.102	.5403	.101	.5387	.101	.5371	.101	.5354	.100	.5339	.100	.5324	.100	.5308	.100	.5293	.100	.5279	.100	1290
.5586	.101	.5568	.100	.5551	.100	.5534	.100	.5517	.099	.5500	.099	.5484	.099	.5468	.098	.5452	.098	.5437	.098	.5422	.098	.5407	.098	.5393	.098	1300
.5695	.100	.5677	.099	.5660	.099	.5643	.099	.5626	.099	.5610	.099	.5593	.099	.5577	.098	.5562	.098	.5546	.098	.5532	.098	.5517	.098	.5502	.098	1310
.5799	.097	.5781	.096	.5763	.096	.5746	.096	.5730	.096	.5714	.096	.5697	.096	.5681	.095	.5666	.095	.5650	.095	.5635	.095	.5620	.095	.5606	.095	1320
.5901	.096	.5883	.096	.5865	.096	.5848	.096	.5831	.096	.5815	.096	.5799	.096	.5783	.095	.5767	.095	.5751	.095	.5736	.095	.5721	.095	.5707	.095	1330
.5998	.095	.5980	.095	.5963	.095	.5945	.095	.5928	.094	.5912	.094	.5896	.094	.5880	.094	.5865	.094	.5849	.094	.5834	.094	.5819	.094	.5805	.094	1340
.6093	.094	.6075	.094	.6057	.094	.6040	.094	.6023	.093	.6007	.093	.5990	.093	.5974	.093	.5958	.093	.5943	.093	.5928	.093	.5914	.093	.5899	.093	1350
.6182	.092	.6164	.092	.6147	.092	.6130	.092	.6113	.092	.6097	.092	.6081	.092	.6065	.091	.6049	.091	.6034	.091	.6018	.091	.6003	.091	.5980	.091	1360
.6270	.091	.6251	.091	.6234	.091	.6216	.091	.6199	.090	.6183	.090	.6167	.090	.6151	.090	.6135	.090	.6120	.090	.6106	.090	.6090	.090	.6076	.090	1370
.6354	.090	.6336	.089	.6317	.089	.6300	.089	.6284	.089	.6268	.089	.6151	.089	.6236	.089	.6220	.089	.6204	.089	.6189	.089	.6174	.089	.6160	.089	1380
.6436	.089	.6418	.088	.6400	.088	.6383	.088	.6366	.088	.6350	.088	.6334	.088	.6317	.087	.6301	.087	.6286	.087	.6271	.087	.6256	.087	.6242	.087	1390
.6515	.087	.6496	.087	.6479	.087	.6461	.087	.6444	.087	.6428	.086	.6412	.086	.6396	.086	.6380	.086	.6365	.086	.6350	.086	.6335	.086	.6320	.086	1400
.6591	.086	.6572	.086	.6555	.086	.6538	.086	.6521	.086	.6505	.086	.6488	.086	.6472	.085	.6456	.085	.6440	.085	.6426	.085	.6411	.085	.6397	.085	1410
.6663	.084	.6645	.084	.6628	.084	.6611	.084	.6593	.084	.6577	.084	.6561	.084	.6545	.084	.6529	.084	.6514	.084	.6499	.084	.6485	.084	.6470	.084	1420
.6736	.084	.6718	.084	.6701	.084	.6683	.084	.6666	.084	.6650	.084	.6634	.084	.6618	.084	.6603	.084	.6588	.084	.6572	.084	.6557	.084	.6543	.084	1430
.6805	.082	.6787	.082	.6770	.082	.6752	.082	.6736	.082	.6719	.082	.6703	.082	.6688	.082	.6672	.082	.6656	.082	.6641	.082	.6626	.082	.6611	.082	1440
.6872	.080	.6854	.080	.6836	.080	.6820	.080	.6803	.080	.6787	.080	.6771	.080	.6754	.080	.6738	.080	.6723	.080	.6708	.080	.6693	.080	.6679	.080	1450
.6938	.080	.6920	.080	.6903	.080	.6886	.080	.6869	.080	.6853	.080	.6837	.080	.6820	.080	.6804	.080	.6789	.080	.6773	.080	.6759	.080	.6745	.080	1460
.7003	.078	.6984	.078	.6967	.078	.6950	.078	.6933	.078	.6916	.078	.6900	.078	.6884	.078	.6868	.078	.6853	.078	.6838	.078	.6823	.078	.6809	.078	1470
.7063	.077	.7045	.077	.7028	.077	.7010	.077	.6994	.077	.6978	.077	.6962	.077	.6946	.077	.6930	.077	.6914	.077	.6899	.077	.6884	.077	.6870	.077	1480
.7124	.077	.7106	.077	.7088	.077	.7071	.077	.7055	.077	.7038	.077	.7023	.077	.7006	.077	.6991	.077	.6975	.077	.6960	.077	.6945	.077	.6931	.077	1490
.7183	.076	.7165	.076	.7147	.076	.7131	.076	.7114	.076	.7098	.076	.7082	.076	.7065	.076	.7049	.076	.7034	.076	.7019	.076	.7004	.076	.6990	.076	1500

NOTE—The characteristics of the logarithms in Table 1A are not given. They are 0. for all values up to 1070 of "weight in grams of one liter of wet pulp," and for the last few columns of 1070. For all values above 1070 and most of 1070 the value is 1. The point of change of the characteristic from zero to unity can be seen by the change of the mantissa from .009+ to .000—. It can also be determined by looking up the antilogarithm in Table 1, and determining as usual in such work the characteristic of the logarithm of that number.

13 Determination by J. M. Tippett. Personal communication.

14 Determination by M. T. Murray, "Practical Applications of the Specific Gravity or Moisture Flask." "Journ." Chem., Met. and Min. Soc. of S. A., Vol. 12, p. 170.



Curve IIB. **Weight of 1 Cu. Ft. of Wet Pulp.**

$$a = \frac{m + cd}{V} \qquad S = \frac{m}{(V - c)}$$

Solving for c, equating values, simplifying and solving for m:

$$m = \frac{SV\,(a - d)}{(S - d)}$$

P is obtained by multiplying the above value of m by 100 and dividing by the weight of the wet pulp, Va:

$$P = \frac{100\,S\,(a - d)}{a\,(S - d)}$$

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It has been generally supposed that the difference between the specific gravity of the average mill solution and that of water was so slight that the error introduced through this source would be negligible. The results previously given for the specific gravity of mill solutions indicate that there is considerable variation. This variation in many cases bears no fixed relationship to the cyanide strength and alkalinity of the solution. The specific gravity is governed to no small extent by other salts which accumulate in solution and in certain cases to foreign salts which are added to perform

TABLE II. WEIGHT IN POUNDS OF ONE CUBIC FOOT OF WET PULP

Formula: 62.42 a

Weight of One Liter of Wet Pulp

Wt. of One Liter of Wet Pulp	1010	1020	1030	1040	1050	1060	1070	1080	1090	1100	1110	1120	1130	1140	1150	1160	1170	1180	1190	1200	1210	1220	1230	1240	1250
Wt. of 1 Cu. Ft. of Wet Pulp	63.04	63.66	64.28	64.91	65.54	66.16	66.79	67.41	68.03	68.66	69.28	69.90	70.53	71.16	71.78	72.41	73.03	73.65	74.27	74.90	75.53	76.15	76.77	77.39	78.02

TABLE II. WEIGHT IN POUNDS OF ONE CUBIC FOOT OF WET PULP—Continued

Wt. of One Liter of Wet Pulp	1260	1270	1280	1290	1300	1310	1320	1330	1340	1350	1360	1370	1380	1390	1400	1410	1420	1430	1440	1450	1460	1470	1480	1490	1500
Wt. of 1 Cu. Ft. of Wet Pulp	78.65	79.27	79.89	80.52	81.14	81.77	82.39	83.02	83.64	84.26	84.88	85.51	86.14	86.76	87.38	88.00	88.63	89.25	89.88	90.51	91.13	91.35	92.38	93.00	93.63

TABLE IIA. LOGARITHMS OF WEIGHT OF ONE CUBIC FOOT OF WET PULP

The Characteristic of All Logarithms in This Table is 1

Wt. of One Liter of Wet Pulp	1010	1020	1030	1040	1050	1060	1070	1080	1090	1100	1110	1120	1130	1140	1150	1160	1170	1180	1190	1200	1210	1220	1230	1240	1250
Logs. of Wt. of One Cu. Ft. Wet Pulp	.7996	.8039	8081	.8123	.8165	.8206	.8247	.8287	.8327	8367	.8406	.8445	.8484	.8522	.8560	.8598	.8635	.8672	.8708	.8743	.8781	.8817	.8852	.8887	.8922

TABLE IIA. LOGARITHMS OF WEIGHT OF ONE CUBIC FOOT OF WET PULP—Continued

Wt. of One Liter of Wet Pulp	1260	1270	1280	1290	1300	1310	1320	1330	1340	1350	1360	1370	1380	1390	1400	1410	1420	1430	1440	1450	1460	1470	1480	1490	1500
Logs. of Wt. of One Cu. Ft. Wet Pulp	8957	.8991	.9025	.9059	.9092	9126	9159	.9192	.9224	9256	9288	.9320	.9352	.9383	.9414	.9445	.9476	.9506	.9537	.9567	.9597	.9626	.9656	.9685	.9714

TABLE III. POUNDS OF DRY SLIME IN ONE CUBIC FOOT OF WET PULP

Formula: $62.42\,a\,\frac{P}{100}$

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp

	2.50	Correction	2.52	Correction	2.54	Correction	2.56	Correction	2.58	Correction	2.60	Correction	2.62	Correction	2.64	Correction	2.66	Correction	2.68	Correction	2.70	Correction	2.72	Correction	2.74	Correction
1010	1923		1933		1943		1953		1963		1972		1981		1990		1999		2008		2017		2026		2034	
1020	961.4	94.9	966.3	95.4	971.4	95.9	976.4	96.4	981.2	96 9	985.8	97.3	990.6	97.8	995.2	98.3	999.8	98.8	1004	99.3	1009	99.7	1013	100.1	1017	100.5
1030	640.9	31.41	644.2	31.59	647.6	31.76	650.9	31.93	654.1	32.09	657.2	32.26	660.3	32.42	663.4	32.58	666.5	32.73	669.5	32.89	672.4	33.10	675.3	33.2	678.2	33.30
1040	480.6	15.60	483.1	15.69	485.6	15.78	488.1	15 87	490.5	15.95	492.9	16.03	495.2	16.11	497.5	16.19	499.8	16.27	502.1	16.35	504.3	16.43	506.4	16.50	508.5	16.58
1050	384.5	9.29	386.5	9.35	388.5	9.40	390.5	9.45	392.4	9.50	394.3	9.55	396.2	9.60	398.0	9.65	399.9	9.69	401.7	9.74	403.4	9.79	405.1	9.84	406.8	9.88
1060	320.4	6.15	322 0	6.19	323.7	6.23	325.4	6.26	327.0	6.29	328.5	6.33	330.1	6.36	331.7	6.40	333.2	6.43	334.7	6.46	336.1	6.49	337.6	6.52	339.0	6.55
1070	274.7	4.36	276.1	4.39	277.5	4.42	278.9	4.44	280.3	4.46	281.7	4.48	283.0	4.51	284.3	4.53	285.6	4.56	286.9	4.58	288.1	4.60	289.4	4.62	290.6	4.64
1080	240.3	3.25	241.5	3.28	242.8	3.30	244.1	3.32	245.3	3.33	246.4	3.35	247.6	3.37	248.8	3.39	249.9	3.40	251.0	3.42	252.1	3.44	253.2	3.45	254.3	3.47
1090	213.6	2.51	214.7	2.53	215.9	2.54	217.0	2.55	218.1	2.56	219.1	2.58	220.1	2.60	221.2	2.61	222.2	2.62	223.2	2.64	224.1	2.66	225.1	2.67	226.0	2.68
1100	192.3	1.99	193.3	2.00	194.3	2.02	195.3	2.03	196.2	2.05	197.2	2.06	198.1	2.07	199.0	2.08	199.9	2.10	200.8	2.11	201.7	2.11	202.6	2.12	203.4	2.13
1110	174.8	1.62	175.7	1.63	176.6	1.64	177.5	1.65	178.4	1.66	179.2	1.67	180.1	1.68	180.9	1.69	181.8	1.70	182.6	1.71	183.4	1.71	184.2	1.72	184.9	1.73
1120	160.2	1.34	161.0	1.35	161.9	1.36	162.7	1.37	163.5	1.38	164.3	1.38	165.1	1.39	165.8	1.40	166.6	1.41	167.4	1.41	168.1	1.42	168.8	1.43	169.5	1.43
1130	147.9	1.12	148.7	1.13	149.4	1.14	150.2	1.14	151.0	1.15	151.7	1.16	152.4	1.17	153.1	1.17	153.8	1.18	154.5	1.19	155.2	1.19	155.8	1.20	156.5	1.20
1140	137.3	.96	138.0	.96	138.8	.97	139.5	.97	140.2	.98	140.8	.99	141.5	1.00	142.2	1.00	142.8	1.01	143.5	1.01	144.1	1.02	144.7	1.03	145.3	1.03
1150	128.2	.82	128.8	.83	129.5	.84	130.2	.84	130.8	.85	131.4	.85	132.1	.85	132.7	.86	133.3	.87	133.9	.87	134.5	.88	135.0	.89	135.6	.89
1160	120.2	.71	120.8	.72	121.4	.73	122.0	.73	122.6	.74	123.2	.74	123.8	.75	124.4	.75	125.0	.75	125.5	.76	126.1	.76	126.6	.77	127.1	.77
1170	113.1	.63	113.7	.63	114.3	.63	114.9	.63	115.5	.64	116.0	.64	116.5	.65	117.1	.65	117.6	.66	118.2	.66	118.7	.66	119.2	.67	119.7	.67
1180	106.8	.56	107.4	.56	107.9	.57	108.5	.57	109.0	.57	109.5	.57	110.1	.57	110.6	.57	111.1	.58	111.6	.59	112.0	.59	112.5	.60	113.0	.60
1190	101.2	.49	101.7	.49	102.2	.50	102.8	.50	103.3	.50	103.8	.50	104.3	.51	104.7	.51	105.2	.52	105.7	.52	106.1	.52	106.6	.53	107.1	.53
1200	96.14	.44	96.63	.44	97.14	.45	97.64	.45	98.12	.45	98.58	.45	99.06	.45	99.52	.46	99.98	.46	100.4	.47	100.9	.47	101.3	.47	101.7	.47
1210	91.56	.394	92.03	.398	92.51	.401	92.98	.404	93.44	.406	93.89	.409	94.34	.411	94.78	.414	95.21	.417	95.64	.420	96.06	.420	86.47	.42	96.88	.42
1220	87.39	.356	87.85	.359	88.31	.361	88.76	.363	89.20	.365	89.63	.368	90.05	.371	90.47	.374	90.89	.376	91.30	.378	91.70	.381	92.09	.383	92.48	.385
1230	83.59	.323	84.03	.325	84.47	.327	84.90	.329	85.32	.331	85.73	.333	86.14	.336	86.54	.338	86.94	.340	87.33	.343	87.71	.345	88.09	.347	88.46	.349
1240	80.11	.293	80.53	.296	80.95	.298	81.36	.300	81.76	.302	82.16	.304	82.55	.306	82.93	.308	83.31	.311	83.69	.313	84.05	.316	84.41	.317	84.77	.318
1250	76.91	.266	77.31	.269	77.71	.272	78.11	.274	78.50	.275	78.88	.277	79.25	.279	79.62	.281	79.99	.283	80.35	.285	80.70	.287	81.04	.289	81.38	.290
1260	73.94	.246	74.32	.248	74.71	.250	75.09	.252	75.47	.253	75.83	.255	76.19	.257	76.54	.259	76.90	.261	77.24	.263	77.58	.264	77.91	.266	78.24	.267
1270	71.20	.225	71.57	.227	71.94	.229	72.31	.231	72.67	.232	73.02	.234	73.37	.235	73.71	.237	74.05	.239	74.38	.241	74.70	.242	75.02	.244	75.34	.245
1280	68.66	.207	69.01	.209	69.37	.211	69.73	.212	70.08	.214	70.41	.216	70.74	.217	71.07	.219	71.40	.221	71.72	.222	72.03	.223	72.34	.225	72.64	.226
1290	66.30	.190	66.64	.192	66.99	.194	67.33	.195	67.67	.197	67.99	.198	68.31	.200	68.63	.202	68.95	.203	69.26	.204	69.55	.206	69.85	.207	70.15	.208
1300	64.09	.177	64.42	.179	64.76	.180	65.09	.181	65.41	.183	65.72	.184	66.03	.186	66.34	.188	66.65	.189	66.95	.190	67.24	.191	67.53	.192	67.81	.193
1310	62.02	.165	62.33	.167	62.66	.168	62.98	.169	63.30	.171	63.60	.172	63.90	.173	64.19	.175	64.49	.177	64.78	.178	65.06	.179	65.34	.180	65.62	.181
1320	60.09	.151	60.40	.153	60.71	.154	61.02	.155	61.33	.157	61.63	.158	61.92	.159	62.20	.161	62.49	.162	62.77	.163	63.04	.164	63.31	.165	63.58	.166
1330	58.26	.143	58.56	.144	58.87	.145	59.17	.146	59.47	.148	59.75	.149	60.03	.150	60.31	.151	60.59	.152	60.87	.153	61.13	.154	61.39	.155	61.65	.156
1340	56.54	.134	56.83	.135	57.13	.136	57.42	.137	57.71	.138	57.99	.139	58.26	.140	58.53	.141	58.80	.142	59.07	.143	59.32	.144	59.58	.145	59.83	.146
1350	54.93	.124	55.21	.125	55.50	.126	55.78	.127	56.06	.128	56.33	.129	56.60	.130	56.86	.131	57.13	.132	57.39	.133	57.63	.134	57.88	.135	58.12	.136
1360	53.41	.116	53.68	.117	53.96	.118	54.24	.119	54.51	.120	54.77	.121	55.03	.122	55.28	.123	55.54	.124	55.79	.125	56.03	.125	56.27	.126	56.51	.127
1370	51.96	.109	52.23	.110	52.50	.111	52.77	.112	53.04	.113	53.29	.114	53.54	.115	53.79	.116	54.04	.117	54.28	.118	54.51	.119	54.75	.120	54.98	.121
1380	50.59	.103	50.85	.103	51.12	.104	51.38	.105	51.64	.106	51.88	.107	52.13	.108	52.37	.108	52.62	.109	52.86	.110	53.09	.111	53.31	.112	53.53	.113
1390	49.29	.097	49.55	.098	49.81	.099	50.06	.099	50.31	.100	50.55	.101	50.79	.102	51.03	.103	51.26	.104	51.49	.105	51.71	.106	51.93	.107	52.15	.107
1400	48.06	.091	48.31	.092	48.56	.093	48.81	.093	49.05	.094	49.29	.095	49.52	.096	49.75	.096	49.98	.097	50.21	.098	50.42	.099	50.64	.100	50.85	.101
1410	46.89	.086	47.13	.087	47.38	.088	47.62	.088	47.86	.089	48.09	.090	48.32	.090	48.54	.091	48.77	.092	48.99	.092	49.20	.093	49.41	.094	49.62	.094
1420	45.78	.081	46 02	.082	46.26	.083	46.49	.083	46.72	.084	46.95	.085	47.17	.085	47.39	.086	47.61	.087	47.83	.087	48.03	.088	48.24	.089	48.44	.089
1430	44.71	.077	44.94	.078	45.17	.079	45.40	.079	45.63	.080	45.85	.081	46.07	.081	46.28	.082	46.50	.083	46.71	.083	46.91	.084	47.11	.085	47.31	.085
1440	43.69	.072	13.92	.073	44.15	.074	44.37	.074	44.59	.075	44.81	.076	45.02	.076	15.23	.077	45.44	.078	45.64	.078	45.84	.079	46.04	.080	46.23	.080
1450	42.73	.068	42.95	.069	43.17	.069	43.39	.070	43.61	.070	43.82	.071	44.03	.071	44.23	.072	44.44	.072	44.64	.073	44.83	.073	45.02	.074	45.21	.075
1460	41.79	.065	42.01	.066	42.23	.066	42.44	.067	42.65	.067	42.86	.068	43.06	.069	43.26	.070	43.46	.071	43.66	.071	43.85	.072	44.03	.073	44.22	.073
1470	40.91	.061	41.12	.061	41.33	.062	41.54	.063	41.75	.064	41.95	.065	42.15	.065	42.35	.060	42.54	.066	42.73	.067	42.92	.067	43.10	.068	43.28	.068
1480	40.06	.058	40.26	.058	40.48	.059	40.68	.060	40.89	.060	41.08	.061	41.28	.061	41.47	.062	41.66	.063	41.85	.063	42.02	.064	42.20	.065	42.38	.065
1490	39.24	.055	32.44	.056	39.65	.057	39.85	.057	40.05	.058	40.23	.059	40.43	.059	40.62	.060	40.80	.061	40.99	.061	41.16	.062	41.34	.063	41.51	.063
1500	38.45	.053	38.65	.053	38.85	.054	39.05	.054	39.25	.055	39.43	.056	39.62	.056	39.80	.057	39.99	.058	40.17	.058	40.34	.059	40.51	.059	40.68	.060

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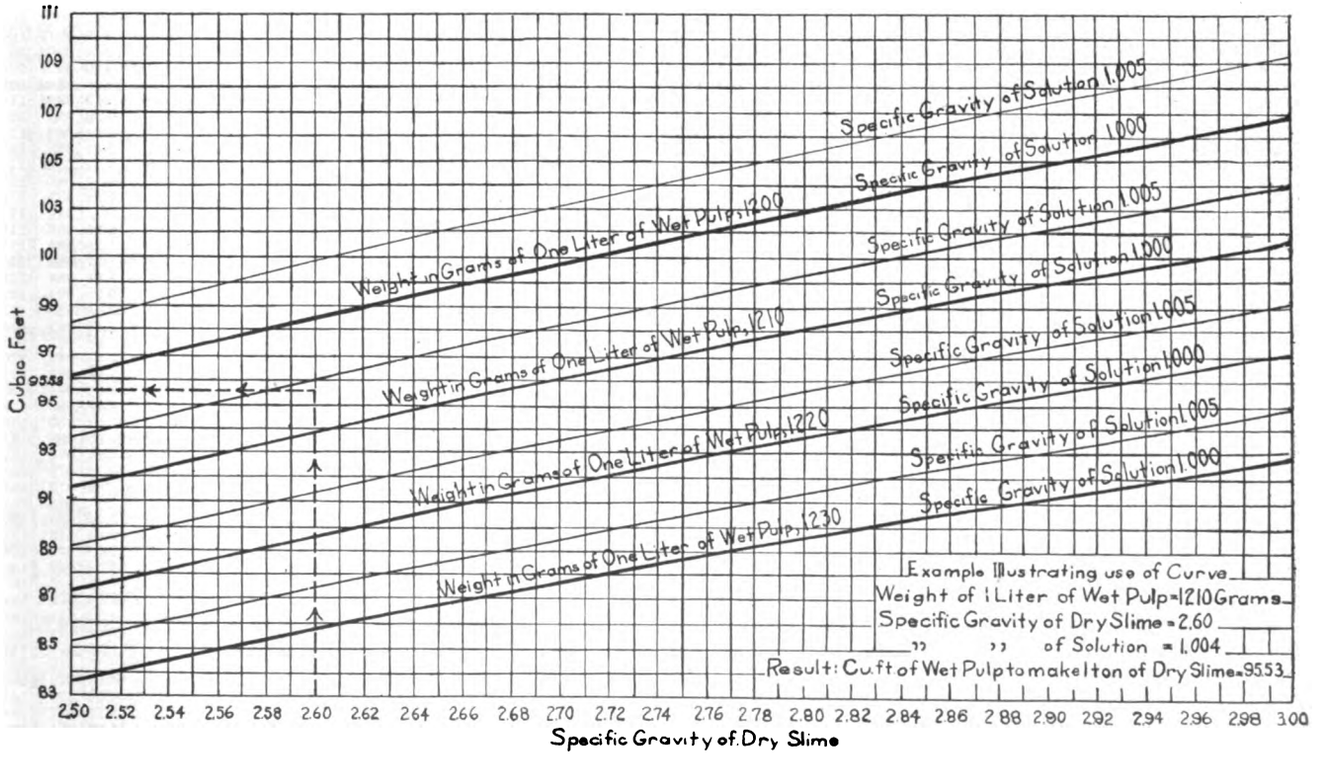
TABLE IIIA. LOGARITHMS OF POUNDS OF DRY SLIME IN ONE CUBIC FOOT OF WET PULP

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp	2.50	Correction	2.52	Correction	2.54	Correction	2.56	Correction	2.58	Correction	2.60	Correction	2.62	Correction	2.64	Correction	2.66	Correction	2.68	Correction	2.70	Correction	2.72	Correction	2.74	Correction
1010	.2840		.2862		.2885		.2907		.2929		.2949		.2969		.2989		.3008		.3028		.3047		.3066		.3084	
1020	.9829	94.9	.9851	95.4	.9874	95.9	.9896	96.4	.9918	96.9	.9938	97.3	.9959	97.8	.9979	98.3	.9990	98.8	.0017	99.3	.0039	99.7	.0056	100.1	.0073	100.5
1030	.8068	31.41	.8090	31.59	.8113	31.76	.8135	31.93	.8156	32.09	.8177	32.26	.8197	32.42	.8218	32.58	.8238	32.73	.8258	32.89	.8276	33.1	.8295	33.2	.8314	33.3
1040	.6818	15.60	.6840	15.69	.6863	15.78	.6885	15.87	.6906	15.95	.6928	16.03	.6948	16.11	.6968	16.19	.6988	16.27	.7008	16.35	.7027	16.43	.7045	16.50	.7063	16.58
1050	.5849	9.29	.5871	9.35	.5894	9.40	.5916	9.45	.5936	9.50	.5958	9.55	.5979	9.60	.5999	9.65	.6020	9.69	.6039	9.74	.6057	9.79	.6076	9.84	.6094	9.88
1060	.5057	6.15	.5079	6.19	.5101	6.23	.5124	6.26	.5145	6.29	.5165	6.33	.5186	6.36	.5207	6.40	.5227	6.43	.5247	6.46	.5265	6.49	.5284	6.52	.5302	6.55
1070	.4389	4.36	.4411	4.39	.4433	4.42	.4454	4.44	.4476	4.46	.4498	4.48	.4518	4.51	.4538	4.53	.4558	4.56	.4577	4.58	.4595	4.60	.4615	4.62	.4633	4.64
1080	.3808	3.25	.3829	3.28	.3852	3.30	.3876	3.32	.3897	3.33	.3916	3.35	.3938	3.37	.3959	3.39	.3978	3.40	.3997	3.42	.4016	3.44	.4035	3.45	.4053	3.47
1090	.3296	2.51	.3318	2.53	.3342	2.54	.3365	2.55	.3387	2.56	.3406	2.58	.3426	2.60	.3448	2.61	.3467	2.62	.3487	2.64	.3504	2.66	.3524	2.67	.3541	2.68
1100	.2840	1.99	.2862	2.00	.2885	2.02	.2907	2.03	.2927	2.05	.2949	2.06	.2969	2.07	.2989	2.08	.3008	2.10	.3028	2.11	.3047	2.11	.3066	2.12	.3084	2.13
1110	.2425	1.62	.2448	1.63	.2470	1.64	.2492	1.65	.2514	1.66	.2534	1.67	.2555	1.68	.2574	1.69	.2596	1.70	.2615	1.71	.2634	1.71	.2653	1.72	.2669	1.73
1120	.2047	1.34	.2068	1.35	.2092	1.36	.2114	1.37	.2135	1.38	.2156	1.38	.2177	1.39	.2196	1.40	.2218	1.41	.2238	1.41	.2256	1.42	.2274	1.43	.2292	1.43
1130	.1700	1.12	.1723	1.13	.1745	1.14	.1767	1.14	.1790	1.15	.1810	1.16	.1830	1.17	.1850	1.17	.1870	1.18	.1889	1.19	.1909	1.19	.1926	1.20	.1945	1.20
1140	.1377	.96	.1400	.96	.1424	.97	.1446	.97	.1467	.98	.1486	.99	.1508	1.00	.1529	1.00	.1547	1.01	.1569	1.01	.1587	1.02	.1605	1.03	.1623	1.03
1150	.1079	.82	.1099	.83	.1123	.84	.1146	.84	.1166	.85	.1186	.85	.1209	.85	.1229	.86	.1248	.87	.1268	.87	.1287	.88	.1303	.89	.1323	.89
1160	.0799	.71	.0821	.72	.0842	.73	.0864	.73	.0885	.74	.0906	.74	.0927	.75	.0948	.75	.0969	.75	.0986	.76	.1007	.76	.1024	.77	.1041	.77
1170	.0535	.63	.0558	.63	.0580	.63	.0603	.63	.0626	.64	.0643	.64	.0663	.65	.0686	.65	.0704	.66	.0726	.66	.0745	.66	.0763	.67	.0781	.67
1180	.0286	.56	.0310	.56	.0330	.57	.0354	.57	.0374	.57	.0394	.57	.0418	.57	.0438	.57	.0457	.58	.0477	.59	.0492	.59	.0512	.60	.0531	.60
1190	.0052	.49	.0073	.49	.0095	.50	.0120	.50	.0141	.50	.0162	.50	.0183	.51	.0199	.51	.0220	.52	.0241	.52	.0257	.52	.0278	.53	.0398	.52
1200	.9829	.44	.9851	.44	.9874	.45	.9896	.45	.9918	.45	.9938	.45	.9959	.45	.9979	.46	.9999	.46	.0017	.47	.0039	.47	.0056	.47	.0073	.47
1210	.9617	.394	.9639	.398	.9662	.401	.9684	.404	.9705	.406	.9726	.409	.9747	.411	.9767	.414	.9787	.417	.9806	.420	.9825	.42	.9844	.42	.9862	.42
1220	.9415	.356	.9437	.359	.9460	.361	.9482	.363	.9504	.365	.9525	.368	.9545	.371	.9565	.374	.9585	.376	.9605	.378	.9624	.381	.9642	.383	.9660	.385
1230	.9222	.323	.9244	.325	.9267	.327	.9289	.329	.9311	.331	.9331	.333	.9357	.336	.9372	.338	.9392	.340	.9412	.343	.9430	.345	.9449	.347	.9467	.345
1240	.9037	.293	.9060	.296	.9082	.298	.9104	.300	.9125	.302	.9147	.304	.9167	.306	.9187	.308	.9207	.311	.9227	.313	.9245	.315	.9264	.317	.9282	.318
1250	.8860	.266	.8882	.269	.8905	.272	.8927	.274	.8949	.275	.8970	.277	.8990	.279	.9010	.281	.9030	.283	.9050	.285	.9069	.287	.9087	.289	.9105	.290
1260	.8689	.246	.8711	.248	.8734	.250	.8756	.252	.8778	.253	.8798	.255	.8819	.257	.8839	.259	.8859	.261	.8878	.263	.8897	.264	.8916	.266	.8934	.267
1270	.8525	.225	.8547	.227	.8570	.229	.8592	.231	.8614	.232	.8634	.234	.8655	.235	.8675	.237	.8695	.239	.8715	.241	.8733	.242	.8752	.244	.8770	.245
1280	.8367	.207	.8389	.209	.8412	.211	.8434	.212	.8456	.214	.8476	.216	.8497	.217	.8517	.219	.8537	.221	.8556	.222	.8575	.223	.8594	.225	.8612	.229
1290	.8215	.190	.8237	.192	.8260	.194	.8282	.195	.8304	.197	.8324	.198	.8345	.200	.8365	.202	.8385	.203	.8405	.204	.8423	.206	.8442	.207	.8460	.208
1300	.8068	.177	.8090	.179	.8113	.180	.8135	.181	.8156	.183	.8177	.184	.8197	.186	.8218	.188	.8238	.189	.8258	.190	.8276	.191	.8295	.192	.8313	.193
1310	.7925	.165	.7947	.167	.7970	.168	.7992	.169	.8014	.171	.8035	.172	.8055	.173	.8075	.175	.8095	.177	.8114	.178	.8133	.179	.8152	.180	.8178	.181
1320	.7788	.151	.7810	.153	.7833	.154	.7855	.155	.7877	.157	.7898	.158	.7918	.159	.7938	.161	.7958	.162	.7978	.163	.7996	.164	.8075	.165	.8033	.169
1330	.7654	.143	.7676	.144	.7699	.145	.7721	.146	.7743	.148	.7763	.149	.7784	.150	.7804	.151	.7824	.152	.7844	.153	.7862	.154	.7881	.155	.7899	.156
1340	.7524	.134	.7546	.135	.7569	.136	.7591	.137	.7612	.138	.7634	.139	.7654	.140	.7674	.141	.7694	.142	.7714	.143	.7732	.144	.7751	.145	.7769	.146
1350	.7398	.124	.7420	.125	.7443	.126	.7465	.127	.7487	.128	.7507	.129	.7528	.130	.7548	.131	.7569	.132	.7588	.133	.7606	.134	.7625	.135	.7643	.136
1360	.7276	.116	.7298	.117	.7321	.118	.7343	.119	.7365	.120	.7385	.121	.7406	.122	.7426	.123	.7446	.124	.7466	.125	.7484	.125	.7503	.126	.7521	.127
1370	.7157	.109	.7179	.110	.7202	.111	.7224	.112	.7246	.113	.7266	.114	.7287	.115	.7307	.116	.7327	.117	.7346	.118	.7365	.119	.7384	.120	.7402	.120
1380	.7041	.103	.7063	.103	.7086	.104	.7108	.105	.7130	.106	.7150	.107	.7171	.108	.7191	.108	.7212	.109	.7231	.110	.7250	.111	.7268	.112	.7286	.113
1390	.6928	.097	.6950	.098	.6973	.099	.6995	.099	.7017	.100	.7037	.101	.7058	.102	.7078	.103	.7098	.104	.7117	.105	.7136	.106	.7154	.107	.7172	.107
1400	.6818	.091	.6840	.092	.6863	.093	.6885	.093	.6906	.094	.6928	.095	.6948	.096	.6968	.096	.6988	.097	.7008	.098	.7026	.099	.7045	.100	.7063	.101
1410	.6711	.086	.6733	.087	.6756	.088	.6778	.088	.6800	.089	.6820	.090	.6841	.090	.6861	.091	.6882	.092	.6901	.092	.6920	.093	.6938	.094	.6956	.094
1420	.6607	.081	.6629	.082	.6652	.083	.6674	.083	.6695	.084	.6716	.085	.6737	.085	.6757	.086	.6777	.087	.6797	.087	.6815	.088	.6834	.089	.6852	.089
1430	.6504	.077	.6526	.078	.6549	.079	.6571	.079	.6592	.080	.6613	.081	.6634	.081	.6654	.082	.6674	.083	.6694	.083	.6713	.084	.6731	.085	.6750	.085
1440	.6404	.072	.6427	.073	.6449	.074	.6471	.074	.6492	.075	.6514	.076	.6534	.076	.6554	.077	.6574	.078	.6594	.078	.6612	.079	.6631	.080	.6649	.080
1450	.6307	.068	.6330	.069	.6352	.069	.6374	.070	.6396	.070	.6417	.071	.6437	.071	.6457	.072	.6478	.072	.6497	.073	.6516	.073	.6534	.074	.6552	.075
1460	.6211	.065	.6234	.066	.6256	.066	.6278	.067	.6299	.067	.6320	.068	.6341	.069	.6361	.070	.6381	.071	.6401	.071	.6420	.072	.6437	.073	.6456	.073
1470	.6118	.061	.6140	.061	.6163	.062	.6185	.063	.6207	.064	.6227	.065	.6248	.065	.6268	.066	.6288	.066	.6307	.067	.6327	.067	.6345	.068	.6363	.068
1480	.6027	.058	.6049	.058	.6072	.059	.6094	.060	.6116	.060	.6136	.061	.6157	.061	.6177	.062	.6197	.063	.6217	.063	.6235	.064	.6253	.065	.6272	.065
1490	.5937	.055	.5959	.056	.5982	.057	.6004	.057	.6026	.058	.6046	.059	.6047	.059	.6087	.060	.6107	.061	.6127	.061	.6145	.062	.6164	.063	.6182	.063
1500	.5849	.053	.5871	.053	.5894	.054	.5916	.054	.5938	.055	.5958	.056	.5979	.056	.5999	.057	.6020	.058	.6039	.058	.6057	.059	.6076	.059	.6084	.060

Note—The natural values are given for the corrections on account of the manner in which the are applied.

Note—The characteristics of the logarithms in the above table can be determined as was done in Table 1. They are all either 0 or 1.



Curve IVB. Cu. Ft. of Pulp to 1 Ton of Dry Slime

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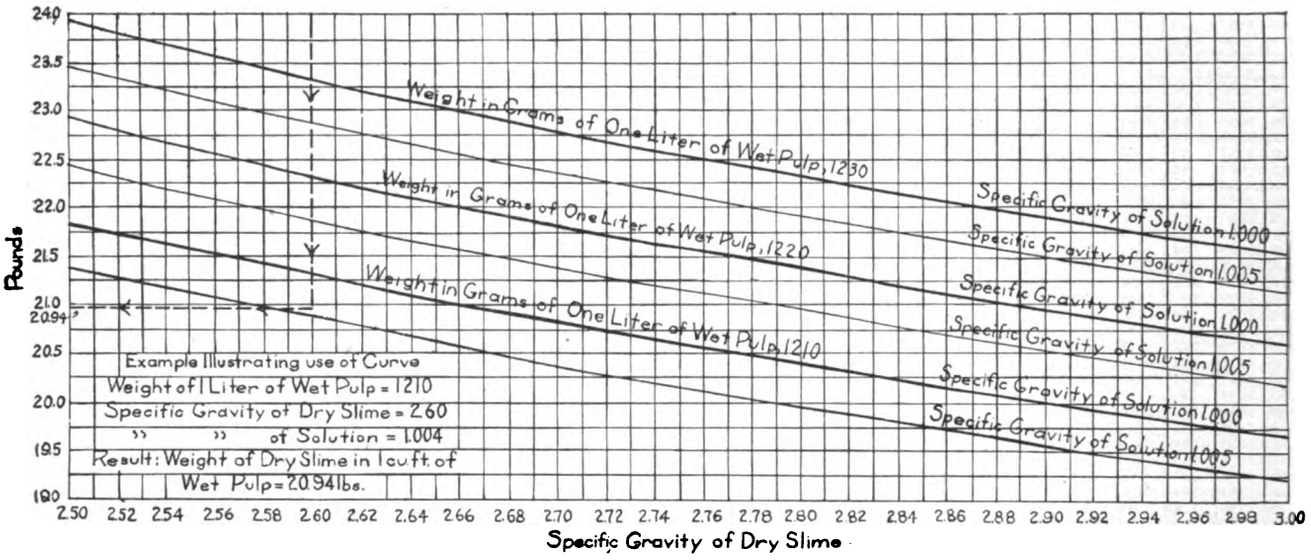
special functions. Hyder's[15] article is a notable exception to this, as he derives the formula taking a general value for the specific gravity of the solutions, and calls particular attention to the error introduced when the specific gravity of the solution is assumed to be 1. Unfortunately most operators do not appear to be familiar with his work. Stadler[16] states that the specific gravity of South African solution is not high enough to cause an im-

[15] "Specific Gravity Estimation of Pulp," Colo. Sci. Soc., Vol. 9, p. 417.

[16] "Practical Applications of the Specific Gravity or Moisture Flask," "Journ." Chem., Met. and Min. Soc. S. A., Vol. 12, p. 170.



Curve IIIB. Weights, in Lbs. of Dry Slime in 1 Cu. Ft. of Wet Pulp

TABLE III. POUNDS OF DRY SLIME IN ONE CUBIC FOOT OF WET PULP—Continued

Formula: $62.42\,a\,\frac{P}{100}$

Specific Gravity of Dry Slime

2.76	Correction	2.78	Correction	2.80	Correction	2.82	Correction	2.84	Correction	2.86	Correction	2.88	Correction	2.90	Correction	2.92	Correction	2.94	Correction	2.96	Correction	2.98	Correction	3.00	Correction	
.9789		.9748		.9709		.9670		.9633		.9598		.9561		.9526		.9493		.9458		.9425		.9393		.9363		1010
1.958	.0973	1.950	.0970	1.942	.0966	1.934	.0962	1.927	.0958	1.920	.0955	1.912	.0951	1.905	.0947	1.898	.0944	1.891	.0940	1.885	.0937	1.878	.0934	1.872	.0931	1020
2.936	.0967	2.924	.0963	2.913	.0960	2.901	.0957	2.890	.0953	2.879	.0949	2.868	.0946	2.858	.0943	2.848	.0939	2.837	.0936	2.827	.0933	2.818	.0930	2.809	.0927	1030
3.916	.0963	3.900	.0959	3.884	.0955	3.869	.0952	3.854	.0949	3.840	.0945	3.825	.0941	3.811	.0938	3.797	.0935	3.784	.0932	3.771	.0929	3.758	.0926	3.745	.0923	1040
4.895	.0956	4.874	.0952	4.854	.0948	4.835	.0945	4.817	.0942	4.799	.0939	4.781	.0935	4.763	.0932	4.746	.0929	4.729	.0926	4.713	.0923	4.697	.0920	4.682	.0918	1050
5.873	.0951	5.849	.0947	5.826	.0944	5.803	.0941	5.781	.0938	5.759	.0934	5.737	.0931	5.716	.0928	5.696	.0925	5.676	.0922	5.656	.0919	5.637	.0916	5.618	.0914	1060
6.852	.0944	6.823	.0940	6.796	.0937	6.769	.0934	6.744	.0931	6.719	.0928	6.693	.0925	6.668	.0922	6.644	.0919	6.621	.0916	6.598	.0913	6.575	.0910	6.554	.0908	1070
7.831	.0940	7.798	.0936	7.767	.0933	7.736	.0930	7.707	.0927	7.678	.0923	7.649	.0920	7.621	.0918	7.594	.0915	7.567	.0913	7.541	.0910	7.515	.0907	7.490	.0904	1080
8.808	.0932	8.772	.0929	8.738	.0927	8.702	.0924	8.669	.0921	8.637	.0917	8.604	.0914	8.572	.0911	8.542	.0909	8.512	.0906	8.482	.0903	8.453	.0901	8.426	.0899	1090
9.789	.0930	9.748	.0926	9.709	.0923	9.670	.0920	9.633	.0917	9.597	.0913	9.561	.0910	9.526	.0908	9.492	.0905	9.458	.0903	9.425	.0900	9.393	.0898	9.363	.0896	1100
10.77	.092	10.72	.092	10.68	.092	10.64	.092	10.60	.091	10.56	.091	10.52	.091	10.48	.090	10.44	.090	10.40	.089	10.37	.089	10.33	.089	10.30	.089	1110
11.75	.092	11.70	.091	11.65	.091	11.60	.091	11.56	.091	11.52	.091	11.47	.090	11.43	.090	11.39	.090	11.35	.089	11.31	.089	11.27	.089	11.24	.089	1120
12.72	.091	12.67	.091	12.62	.090	12.57	.090	12.52	.090	12.48	.090	12.43	.089	12.38	.089	12.34	.089	12.29	.088	12.25	.088	12.21	.088	12.17	.088	1130
13.70	.090	13.65	.090	13.59	.090	13.54	.090	13.49	.090	13.44	.090	13.39	.089	13.34	.089	13.29	.089	13.24	.088	13.20	.088	13.15	.088	13.11	.088	1140
14.68	.090	14.62	.090	14.56	.089	14.50	.089	14.45	.089	14.40	.089	14.34	.088	14.29	.088	14.24	.088	14.19	.088	14.14	.087	14.09	.087	14.04	.087	1150
15.66	.089	15.60	.088	15.53	.088	15.47	.088	15.41	.088	15.36	.088	15.30	.088	15.24	.088	15.19	.087	15.13	.087	15.08	.087	15.03	.087	14.98	.087	1160
16.64	.089	16.57	.088	16.50	.088	16.44	.088	16.38	.088	16.31	.087	16.25	.087	16.19	.087	16.14	.087	16.08	.087	16.02	.086	15.97	.086	15.91	.086	1170
17.62	.089	17.55	.088	17.48	.088	17.41	.088	17.34	.088	17.28	.087	17.21	.087	17.15	.087	17.09	.087	17.03	.087	16.97	.086	16.91	.086	16.85	.086	1180
18.60	.088	18.52	.088	18.45	.088	18.38	.088	18.31	.088	18.24	.087	18.17	.087	18.10	.086	18.04	.086	17.97	.086	17.91	.086	17.85	.086	17.79	.085	1190
19.58	.087	19.50	.087	19.42	.087	19.34	.087	19.27	.087	19.20	.086	19.12	.086	19.05	.085	18.98	.085	18.91	.085	18.85	.084	18.78	.084	18.72	.084	1200
20.55	.086	20.47	.086	20.39	.086	20.31	.086	20.23	.086	20.16	.086	20.08	.085	20.00	.085	19.93	.085	19.86	.085	19.79	.084	19.72	.084	19.66	.084	1210
21.53	.086	21.44	.086	21.36	.086	21.27	.086	21.19	.086	21.12	.086	21.04	.085	20.96	.085	20.88	.085	20.81	.085	20.73	.084	20.66	.084	20.60	.084	1220
22.51	.085	22.42	.085	22.33	.085	22.24	.085	22.16	.085	22.08	.085	21.99	.084	21.91	.084	21.83	.084	21.75	.084	21.68	.083	21.60	.083	21.53	.083	1230
23.49	.085	23.39	.085	23.30	.085	23.21	.085	23.12	.085	23.04	.085	22.95	.084	22.86	.084	22.78	.084	22.70	.084	22.62	.083	22.54	.083	22.47	.083	1240
24.47	.084	24.37	.084	24.27	.084	24.17	.084	24.08	.084	23.99	.084	23.90	.083	23.81	.083	23.73	.083	23.64	.083	23.56	.082	23.48	.082	23.40	.082	1250
25.45	.084	25.35	.084	25.25	.084	25.15	.084	25.05	.084	24.96	.084	24.86	.083	24.77	.083	24.68	.083	24.60	.083	24.51	.082	24.42	.082	24.34	.082	1260
26.43	.084	26.32	.083	26.22	.083	26.11	.083	26.01	.083	25.92	.083	25.82	.083	25.72	.082	25.63	.082	25.54	.082	25.45	.082	25.36	.082	25.28	.082	1270
27.41	.083	27.30	.083	27.19	.083	27.08	.083	26.98	.083	26.88	.082	26.77	.082	26.67	.082	26.58	.081	26.49	.081	26.39	.081	26.30	.081	26.22	.081	1280
28.39	.082	28.27	.082	28.16	.082	28.05	.082	27.94	.082	27.84	.082	27.73	.082	27.63	.082	27.53	.081	27.43	.081	27.33	.081	27.24	.080	27.15	.080	1290
29.36	.082	29.24	.082	29.13	.082	29.01	.082	28.90	.082	28.79	.081	28.68	.081	28.58	.081	28.48	.080	28.37	.080	28.27	.080	28.18	.080	28.09	.080	1300
30.35	.082	30.22	.082	30.10	.081	29.98	.081	29.87	.081	29.76	.081	29.64	.081	29.53	.081	29.43	.080	29.32	.080	29.22	.080	29.12	.080	29.03	.080	1310
31.32	.080	31.19	.080	31.07	.080	30.94	.080	30.82	.080	30.71	.080	30.59	.080	30.48	.080	30.37	.079	30.26	.079	30.16	.079	30.06	.079	29.96	.079	1320
32.30	.080	32.17	.080	32.04	.080	31.91	.080	31.79	.080	31.67	.080	31.55	.080	31.43	.080	31.32	.079	31.21	.079	31.10	.079	31.00	.079	30.90	.079	1330
33.28	.080	33.14	.080	33.01	.079	32.88	.079	32.76	.079	32.63	.079	32.51	.079	32.39	.079	32.28	.079	32.16	.079	32.05	.079	31.94	.079	31.83	.079	1340
34.26	.079	34.12	.079	33.99	.079	33.85	.079	33.72	.079	33.60	.079	33.47	.079	33.35	.079	33.23	.078	33.11	.078	32.99	.078	32.88	.078	32.77	.078	1350
35.24	.078	35.09	.078	34.95	.078	34.81	.078	34.68	.078	34.55	.077	34.42	.077	34.29	.077	34.17	.077	34.05	.077	33.93	.077	33.81	.077	33.70	.077	1360
36.22	.078	36.07	.078	35.92	.077	35.78	.077	35.64	.077	35.51	.077	35.38	.077	35.25	.077	35.12	.077	34.99	.077	34.87	.077	34.75	.076	34.64	.076	1370
37.20	.078	37.05	.078	36.90	.077	36.75	.077	36.61	.077	36.47	.077	36.33	.077	36.20	.077	36.07	.077	35.94	.077	35.82	.077	35.70	.076	35.58	.076	1380
38.18	.077	38.02	.077	37.87	.077	37.72	.077	37.58	.077	37.44	.077	37.29	.077	37.15	.077	37.02	.076	36.89	.076	36.76	.076	36.64	.076	36.52	.076	1390
39.16	.076	39.00	.076	38.84	.076	38.69	.076	38.54	.076	38.40	.076	38.25	.076	38.11	.076	37.97	.075	37.84	.075	37.71	.075	37.58	.075	37.45	.075	1400
40.14	.076	39.97	.076	39.81	.075	39.65	.075	39.50	.075	39.35	.075	39.20	.075	39.06	.075	38.92	.075	38.78	.075	38.65	.075	38.52	.075	38.39	.075	1410
41.11	.075	40.94	.075	40.78	.074	40.62	.074	40.46	.074	40.30	.075	40.15	.075	40.00	.075	39.86	.074	39.72	.074	39.58	.074	39.45	.074	39.32	.074	1420
42.09	.075	41.92	.075	41.75	.074	41.58	.074	41.43	.074	41.28	.075	41.12	.075	40.97	.075	40.82	.074	40.67	.074	40.53	.074	40.39	.074	40.26	.074	1430
43.07	.073	42.89	.073	42.72	.073	42.55	.073	42.39	.073	42.23	.073	42.07	.073	41.92	.073	41.77	.073	41.62	.073	41.47	.073	41.33	.073	41.20	.073	1440
44.05	.073	43.87	.073	43.69	.073	43.52	.073	43.35	.073	43.19	.073	43.03	.072	42.87	.072	42.71	.072	42.56	.072	42.41	.072	42.37	.072	42.13	.072	1450
45.03	.073	44.84	.073	44.66	.073	44.49	.073	44.32	.073	44.15	.073	43.99	.072	43.83	.072	43.67	.072	43.51	.072	43.36	.072	43.21	.072	43.07	.072	1460
46.00	.071	45.81	.071	45.63	.071	45.45	.071	45.28	.071	45.11	.071	44.94	.071	44.78	.071	44.62	.071	44.46	.071	44.30	.071	44.15	.071	44.00	.071	1470
46.98	.071	46.79	.071	46.60	.071	46.42	.071	46.24	.071	46.06	.071	45.89	.071	45.72	.071	45.56	.071	45.40	.071	45.24	.071	45.08	.071	44.93	.071	1480
47.96	.071	47.76	.071	47.57	.071	47.39	.071	47.21	.071	47.03	.071	46.85	.071	46.68	.071	46.51	.071	46.35	.071	46.19	.071	46.03	.071	45.88	.071	1490
48.95	.071	48.74	.071	48.54	.071	48.35	.071	48.17	.071	47.99	.071	47.81	.071	47.63	.071	47.46	.071	47.29	.071	47.13	.071	46.97	.071	46.81	.071	1500

Weight in Grams of One Liter of Wet Pulp

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portant error in estimating the tonnage of dry slime. Sharwood[17] has called attention to the fact that with excessively thin mixtures, such as the overflow of dams or clarifying tanks, the dissolved salts in the water may have an important influence upon the determination of the solids in suspension.

The percentage of difference in this case would be 7.49.

It will be noted that as the percentage of solids in the pulp decreases the percentage of error from this source increases.

In the hydrometallurgy of copper, which is now

TABLE 111-A. LOGARITHMS OF POUNDS OF DRY SLIME IN ONE CUBIC FOOT OF WET PULP—Continued

Specific Gravity of Dry Slime

2.76	Correction	2.78	Correction	2.80	Correction	2.82	Correction	2.84	Correction	2.86	Correction	2.88	Correction	2.90	Correction	2.92	Correction	2.94	Correction	2.96	Correction	2.98	Correction	3.00	Correction	Weight in Grams of One Liter of Wet Pulp
.9907		.9889		.9872		.9854		.9838		.9822		.9805		.9789		.9774		.9758		.9743		.9728		.9714		1010
.2918	.0973	.2900	.0970	.2882	.0966	.2865	.0962	.2849	.0958	.2833	.0955	.2815	.0951	.2799	.0947	.2783	.0944	.2767	.0940	.2753	.0937	.2737	.0934	.2723	.0931	1020
.4678	.0967	.4660	.0963	.4643	.0960	.4625	.0957	.4609	.0953	.4592	.0949	.4576	.0946	.4561	.0943	.4545	.0939	.4529	.0936	.4513	.0933	.4499	.0933	.4486	.0927	1030
.5928	.0963	.5911	.0959	.5893	.0955	.5876	.0952	.5859	.0949	.5843	.0945	.5826	.0941	.5810	.0938	.5794	.0935	.5780	.0932	.5765	.0929	.5750	.0926	.5735	.0923	1040
.6898	.6956	.6879	.0952	.6861	.0948	.6844	.0945	.6828	.0942	.6812	.0939	.6795	.0935	.6779	.0932	.6763	.0929	.6748	.0926	.6733	.0923	.6718	.0920	.6704	.0918	1050
.7689	.0951	.7671	.0947	.7654	.0944	.7637	.0941	.7620	.0938	.7604	.0934	.7587	.0931	.7671	.0928	.7556	.0925	.7540	.0922	.7525	.0919	.7510	.0916	.7496	.0914	1060
.8354	.0944	.8340	.0940	.8323	.0937	.8305	.0934	.8289	.0931	.8273	.0928	.8256	.0925	.8240	.0922	.8224	.0919	.8209	.0916	.8194	.0913	.8179	.0910	.8165	.0908	1070
.8938	.0940	.8920	.0936	.8903	.0933	.8885	.0930	.8869	.0927	.8852	.0923	.8836	.0920	.8820	.0918	.8805	.0915	.8789	.0913	.8774	.0910	.8759	.0907	.8745	.0904	1080
.9449	.0932	.9431	.0929	.9414	.0927	.9396	.0924	.9380	.0921	.9364	.0917	.9347	.0914	.9031	.0911	.9316	.0909	.9300	.0906	.9285	.0903	.9270	.0901	.9256	.0899	1090
.9907	.0930	.9889	.0926	.9872	.0923	.9854	.0920	.9838	.0917	.9821	.0913	.9805	.0910	.9789	.0908	.9774	.0905	.9758	.0903	.9743	.0900	.9728	.0898	.9714	.0899	1100
.0332	.092	.0302	.092	.0286	.092	.0269	.092	.0253	.091	.0237	.091	.0220	.091	.0204	.090	.0187	.089	.0170	.089	.0158	.089	.0141	.089	.0128	.089	1110
.0700	.092	.0682	.091	.0663	.091	.0645	.092	.0630	.091	.0614	.091	.0596	.090	.0580	.090	.0565	.090	.0545	.089	.0535	.089	.0159	.089	.0508	.089	1120
.1045	.091	.1028	.091	.1017	.090	.0993	.090	.0976	.090	.0962	.090	.0945	.089	.0927	.089	.0913	.089	.0896	.088	.0881	.088	.0867	.088	.0853	.088	1130
.1367	.090	.1351	.090	.1332	.090	.1316	.090	.1300	.090	.1284	.090	.1268	.090	.1252	.089	.1235	.089	.1219	.088	.1206	.088	.1189	.088	.1178	.088	1140
.1667	.090	.1649	.090	.1632	.089	.1614	.089	.1599	.089	.1524	.089	.1566	.088	.1550	.088	.1535	.088	.1520	.088	.1504	.087	.1489	.087	.1474	.087	1150
.1948	.089	.1931	.088	.1912	.088	.1895	.088	.1878	.088	.1864	.088	.1847	.088	.1830	.088	.1816	.087	.1798	.087	.1784	.087	.1770	.087	.1755	.087	1160
.2212	.089	.2193	.088	.2175	.088	.2159	.088	.2143	.088	.2125	.087	.2109	.087	.2092	.087	.2079	.087	.2063	.087	.2047	.086	.2033	.086	.2017	.086	1170
.2460	.089	.2443	.088	.2425	.088	.2408	.088	.2391	.088	.2375	.088	.2358	.087	.2343	.087	.2327	.087	.2312	.087	.2297	.086	.2281	.086	.2266	.086	1180
.2695	.088	.2676	.088	.2660	.088	.2643	.088	.2627	.088	.2610	.087	.2594	.087	.2577	.086	.2562	.086	.2545	.086	.2531	.086	.2516	.086	.2502	.085	1190
.2918	.087	.2908	.087	.2882	.087	.2865	.087	.2849	.087	.2833	.086	.2815	.086	.2799	.085	.2783	.085	.2767	.085	.2753	.084	.2737	.084	.2723	.084	1200
.3128	.086	.3111	.086	.3094	.086	.3077	.086	.3060	.086	.3045	.086	.3028	.085	.3010	.085	.2995	.085	.2980	.085	.2983	.084	.2949	.084	.2936	.084	1210
.3330	.086	.3312	.086	.3296	.086	.3278	.086	.3261	.086	.3247	.086	.3239	.085	.3234	.085	.3197	.085	.3183	.085	.3166	.084	.3151	.084	.3139	.084	1220
.3924	.085	.3506	.085	.3489	.085	.3478	.085	.3456	.085	.3440	.085	.3422	.084	.3416	.084	.3391	.084	.3375	.084	.3361	.083	.3345	.083	.3330	.083	1230
.3709	.085	.3693	.085	.3574	.085	.3657	.085	.3640	.085	.3625	.085	.3608	.084	.3591	.084	.3576	.084	.3560	.084	.3545	.083	.3530	.083	.3523	.083	1240
.3886	.084	.3869	.084	.3851	.084	.3833	.084	.3817	.084	.3800	.083	.3784	.083	.3780	.083	.3753	.083	.3736	.083	.3722	.082	.3707	.082	.3692	.082	1250
.4057	.085	.4040	.085	.4023	.084	.4005	.084	.3988	.084	.3972	.084	.3955	.083	.3959	.083	.3923	.083	.3909	.083	.3893	.082	.3877	.082	.3863	.082	1260
.4221	.084	.4203	.083	.4186	.083	.4168	.083	.4151	.083	.4136	.083	.4120	.083	.4108	.082	.4087	.082	.4072	.082	.4057	.082	.4042	.082	.4028	.082	1270
.4379	.083	.4362	.083	.4344	.083	.4326	.083	.4310	.083	.4294	.082	.4276	.082	.4280	.082	.4246	.081	.4231	.081	.4214	.081	.4200	.081	.4186	.081	1280
.4532	.082	.4513	.082	.4496	.082	.4479	.082	.4462	.082	.4447	.082	.4429	.082	.4414	.082	.4398	.081	.4382	.081	.4366	.081	.4352	.080	.4338	.080	1290
.4678	.082	.4660	.082	.4643	.082	.4625	.082	.4609	.082	.4592	.081	.4576	.081	.4581	.081	.4545	.080	.4529	.080	.4513	.080	.4499	.080	.4486	.080	1300
.4822	.082	.4803	.082	.4786	.081	.4768	.081	.4752	.081	.4736	.081	.4719	.081	.4708	.081	.4688	.080	.4672	.080	.4657	.080	.4642	.080	.4628	.080	1310
.4958	.080	.4940	.080	.4923	.080	.4905	.080	.4888	.080	.4873	.079	.4856	.079	.4860	.079	.4824	.079	.4809	.079	.4794	.079	.4780	.079	.4765	.079	1320
.5092	.080	.5075	.080	.5057	.080	.5039	.080	.5023	.080	.5006	.080	.4990	.080	.4983	.080	.4958	.079	.4943	.079	.4928	.079	.4914	.079	.4900	.079	1330
.5222	.080	.5204	.080	.5186	.079	.5169	.079	.5153	.079	.5136	.079	.5120	.079	.5104	.079	.5089	.079	.5073	.079	.5058	.079	.5043	.079	.5028	.079	1340
.5348	.079	.5330	.079	.5313	.079	.5296	.079	.5279	.079	.5263	.079	.5247	.079	.5231	.079	.5215	.078	.5200	.078	.5184	.078	.5169	.078	.5155	.078	1350
.5470	.078	.5452	.078	.5434	.078	.5417	.078	.5401	.078	.5384	.077	.5368	.077	.5352	.077	.5336	.077	.5321	.077	.5306	.077	.5291	.077	.5276	.077	1360
.5589	.078	.5571	.078	.5553	.077	.5536	.077	.5519	.077	.5504	.077	.5488	.077	.5472	.077	.5456	.076	.5439	.076	.5424	.076	.5410	.076	.5396	.076	1370
.5705	.078	.5688	.078	.5670	.078	.5653	.078	.5636	.078	.5619	.077	.5603	.077	.5580	.077	.5572	.077	.5556	.077	.5541	.077	.5527	.077	.5512	.077	1380
.5818	.077	.5800	.077	.5783	.077	.5766	.077	.5750	.077	.5733	.077	.5716	.077	.5700	.077	.5684	.076	.5669	.076	.5654	.076	.5640	.076	.5625	.076	1390
.5928	.076	.5911	.076	.5893	.076	.5876	.076	.5859	.076	.5843	.076	.5826	.076	.5811	.076	.5794	.075	.5780	.075	.5765	.075	.5750	.075	.5734	.075	1400
.6036	.076	.6017	.076	.6000	.075	.5982	.075	.5966	.075	.5949	.075	.5933	.075	.5912	.075	.5902	.075	.5886	.075	.5871	.075	.5857	.075	.5842	.075	1410
.6139	.074	.6121	.074	.6104	.074	.6087	.074	.6070	.074	.6053	.074	.6037	.074	.6028	.074	.6005	.074	.5990	.074	.5975	.074	.5960	.074	.5946	.074	1420
.6242	.075	.6224	.075	.6207	.075	.6189	.075	.6173	.075	.6157	.075	.6140	.075	.6123	.075	.6109	.074	.6093	.074	.6078	.074	.6063	.074	.6049	.074	1430
.6342	.073	.6324	.073	.6306	.073	.6289	.073	.6273	.073	.6256	.073	.6240	.073	.6224	.073	.6209	.073	.6193	.073	.6177	.073	.6163	.073	.6149	.073	1440
.6439	.073	.6422	.073	.6404	.073	.6387	.073	.6370	.073	.6354	.073	.6338	.072	.6322	.072	.6305	.072	.6290	.072	.6275	.072	.6271	.072	.6246	.073	1450
.6535	.073	.6517	.073	.6499	.073	.6483	.073	.6466	.073	.6449	.073	.6434	.073	.6418	.073	.6402	.073	.6386	.073	.6371	.073	.6356	.073	.6342	.072	1460
.6628	.071	.6610	.071	.6592	.071	.6575	.071	.6559	.071	.6543	.071	.6526	.071	.6528	.071	.6495	.071	.6480	.071	.6464	.071	.6449	.071	.6434	.071	1470
.6719	.071	.6702	.071	.6684	.071	.6667	.071	.6650	.071	.6633	.071	.6617	.071	.6604	.071	.6585	.071	.6571	.071	.6555	.071	.6540	.071	.6525	.071	1480
.6809	.071	.6791	.071	.6773	.071	.6757	.071	.6740	.071	.6724	.071	.6707	.071	.6691	.071	.6675	.071	.6660	.071	.6645	.071	.6630	.071	.6616	.071	1490
.6898	.071	.6879	.071	.6861	.071	.6844	.071	.6828	.071	.6812	.071	.6795	.071	.6779	.071	.6763	.071	.6748	.071	.6733	.071	.6718	.071	.6703	.071	1500

NOTE—The characteristics of the logarithms in the above table can be determined as was done in Table 1. They are all either 0 or 1.

[17] "Measurement of Pulp and Tailing," "Min. Mag.," Vol. 1, p. 298.

Variation Due to Specific Gravity of Solution

In order to show the importance of making a correction for the specific gravity of the solution, we give two cases which could readily occur in cyanide practice.

Taking the specific gravity of the dry slime as 2.66 and the weight of one liter of the wet pulp equal to 1260 grams (specific gravity 1.260).

(a) Taking the specific gravity of the solution at 1.000, P = 33.07%.

(b) Taking the specific gravity of the solution as 1.008, P = 32.20%.

The percentage of difference would be 2.63.

Again, taking the specific gravity of the dry slime as 2.66 and the weight of one liter of the wet pulp equal to 1100 grams (specific gravity 1.100).

(a) Taking the specific gravity of the solution as 1.000, P = 14.56%.

(b) Taking the specific gravity of the solution as 1.008, P = 13.47%.

of rapidly increasing importance, solutions having a comparatively high specific gravity are frequently used. In order to show more fully the effect of the specific gravity of the solution upon the percentage of dry slime in wet pulps, and particularly for pulps in which the specific gravity of the solution is higher than that met with in cyanide practice, we have calculated the values given under P and P′ in Table A.

The values given under P have been calculated by substituting in the formula and solving by the use of a five-place logarithmic table.

The values given under P′ have been calculated by taking the value for P when d is 1 and deducting from it a correction arrived at by taking as a constant, the difference between the value for P when d is 1 and when d is 1.010, and multiplying by the number of hundredths, taken as a whole number, by which d is greater than 1. Comparison of the values given for P and P′ in Table A as well as the curves given for both values in Fig. 1, will show the degree of error which would be introduced at various parts of the table by the use of this constant for values of d above 1.

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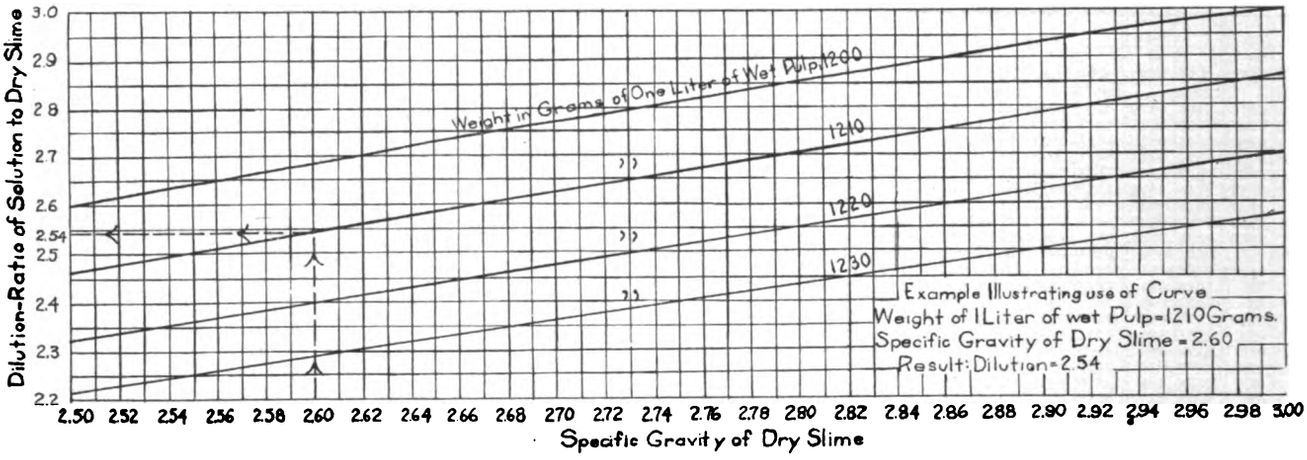
It will be noted that the percentages given under P as the specific gravity of the solution increases do not form a straight line; therefore a constant cannot be given for applying this correction which is accurate throughout the whole range shown by the curves. But we have found that covering the range of the present tables, which have been more particularly calculated for use with the cyanide process, i.e., for values of d up to 1.010, this portion of the curve is so nearly a straight line that to show any curvature of the line between these two points it is necessary to make the computations by considerably more refined methods than those used in calculating the values given in the tables to which this correction is applied: therefore, to keep the tables within reasonable bounds, we have given



Curve Vb. Dilution Ratio of Solution of Dry Slime

TABLE IV. NUMBER OF CUBIC FEET OF WET PULP TO MAKE ONE TON OF DRY SLIME

Formula: $$\frac{2000}{64.42\,a\,\frac{P}{100}}$$

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp	2.50	Correction	2.52	Correction	2.54	Correction	2.56	Correction	2.58	Correction	2.60	Correction	2.62	Correction	2.64	Correction	2.66	Correction	2.68	Correction	2.70	Correction	2.72	Correction	2.74	Correction
1010	1.040		1.035		1.029		1.024		1.019		1.014		1.009		1.005		1.000		.9957		.9915		.9872		.9831	
1020	2.080	.1033	2.070	.1028	2.059	.1023	2.048	.1017	2.038	.1012	2.029	.1008	2.019	.1003	2.010	.0999	2.000	.0994	1.991	.0989	1.983	.0985	1.974	.0981	1.966	.0977
1030	3.120	.1026	3.104	.1021	3.088	.1016	3.072	.1011	3.057	.1006	3.043	.1001	3.028	.0996	3.014	.0992	3.000	.0988	2.987	.0984	2.974	.0979	2.961	.0975	2.949	.0971
1040	4.161	.1020	4.140	.1015	4.118	.1010	4.097	.1005	4.077	.1000	4.058	.0996	4.039	.0992	4.020	.0987	4.001	.0982	3.983	.0978	3.966	.0974	3.949	.0970	3.933	.0966
1050	5.201	.1012	5.175	.1007	5.148	.1003	5.122	.0998	5.097	.0994	5.072	.0989	5.048	.0984	5.025	.0980	5.002	.0976	4.979	.0972	4.957	.0968	4.936	.0964	4.916	.0960
1060	6.242	.1006	6.210	.1001	6.177	.0996	6.146	.0991	6.116	.0987	6.087	.0983	6.058	.0979	6.030	.0974	6.002	.0970	5.975	.0967	5.950	.0963	5.924	.0959	5.899	.0955
1070	7.281	.0998	7.244	.0994	7.207	.0990	7.170	.0985	7.134	.0980	7.100	.0975	7.066	.0971	7.034	.0968	7.002	.0964	6.971	.0961	6.941	.0957	6.911	.0953	6.882	.0948
1080	8.321	.0991	8.279	.0987	8.236	.0983	8.194	.0978	8.154	.0974	8.115	.0969	8.076	.0965	8.039	.0961	8.002	.0958	7.966	.0955	7.932	.0951	7.898	.0948	7.865	.0944
1090	9.360	.0983	9.312	.0979	9.265	.0975	9.217	.0970	9.171	.0966	9.128	.0962	9.085	.0959	9.043	.0955	9.001	.0951	8.960	.0947	8.923	.0944	8.884	.0940	8.847	.0936
1100	10.40	.098	10.35	.098	10.29	.097	10.24	.097	10.19	.096	10.14	.096	10.09	.095	10.05	.095	10.00	.095	9.957	.0944	9.915	.0941	9.873	.0938	9.831	.0934
1110	11.44	.097	11.38	.096	11.32	.096	11.27	.096	11.21	.095	11.16	.095	11.11	.094	11.05	.094	11.00	.094	10.95	.093	10.91	.093	10.86	.093	10.81	.092
1120	12.48	.096	12.42	.096	12.35	.095	12.29	.095	12.23	.095	12.17	.094	12.11	.094	12.06	.093	12.00	.093	11.95	.093	11.90	.093	11.85	.093	11.80	.092
1130	13.52	.095	13.45	.095	13.38	.095	13.31	.094	13.25	.094	13.19	.093	13.12	.093	13.06	.092	13.00	.092	12.94	.092	12.89	.092	12.83	.092	12.78	.091
1140	14.56	.095	14.49	.095	14.41	.094	14.34	.094	14.27	.094	14.20	.093	14.13	.093	14.07	.092	14.00	.092	13.94	.092	13.88	.091	13.82	.091	13.76	.091
1150	15.60	.094	15.52	.094	15.44	.094	15.36	.093	15.29	.093	15.22	.092	15.14	.092	15.07	.091	15.00	.091	14.93	.091	14.87	.091	14.81	.091	14.75	.090
1160	16.64	.093	16.56	.093	16.47	.093	16.39	.092	16.30	.092	16.22	.091	16.15	.091	16.08	.091	16.00	.091	15.93	.091	15.86	.090	15.79	.089	15.73	.089
1170	17.68	.093	17.59	.092	17.50	.092	17.41	.092	17.32	.091	17.24	.091	17.16	.091	17.08	.090	17.00	.090	16.92	.090	16.85	.090	16.78	.089	16.71	.089
1180	18.72	.092	18.63	.092	18.53	.092	18.44	.092	18.34	.091	18.25	.091	18.17	.091	18.09	.090	18.01	.090	17.93	.090	17.85	.090	17.77	.089	17.70	.089
1190	19.77	.092	19.67	.092	19.56	.091	19.46	.091	19.36	.090	19.27	.090	19.18	.090	19.09	.090	19.01	.090	18.92	.089	18.84	.089	18.76	.089	18.68	.089
1200	20.80	.090	20.70	.090	20.59	.090	20.48	.090	20.38	.089	20.29	.089	20.19	.089	20.10	.088	20.00	.088	19.91	.088	19.83	.088	19.74	.087	19.66	.087
1210	21.84	.090	21.73	.090	21.62	.090	21.51	.090	21.40	.089	21.30	.089	21.20	.089	21.10	.088	21.00	.088	20.91	.088	20.82	.087	20.73	.087	20.64	.087
1220	22.88	.089	22.77	.089	22.65	.089	22.53	.089	22.42	.088	22.32	.088	22.21	.088	22.11	.087	22.00	.087	21.90	.087	21.81	.087	21.72	.087	21.63	.087
1230	23.92	.089	23.80	.089	23.68	.089	23.56	.088	23.44	.088	23.33	.087	23.22	.087	23.11	.087	23.00	.086	22.90	.086	22.80	.086	22.70	.086	22.61	.086
1240	24.96	.088	24.84	.088	24.71	.088	24.58	.087	24.46	.087	24.34	.087	24.23	.087	24.12	.086	24.00	.086	23.89	.086	23.79	.086	23.69	.086	23.59	.085
1250	26.00	.087	25.87	.087	25.73	.087	25.60	.087	25.47	.086	25.35	.086	25.24	.086	25.12	.086	25.00	.085	24.89	.085	24.79	.085	24.68	.085	24.58	.085
1260	27.05	.087	26.91	.087	26.77	.087	26.63	.086	26.50	.086	26.38	.086	26.25	.086	26.13	.086	26.01	.085	25.89	.085	25.78	.085	25.67	.085	25.56	.084
1270	28.09	.086	27.94	.086	27.80	.086	27.66	.086	27.52	.085	27.39	.085	27.26	.085	27.13	.085	27.01	.085	26.89	.084	26.77	.084	26.66	.084	26.55	.084
1280	29.13	.085	28.98	.085	28.83	.085	28.68	.084	28.54	.084	28.41	.084	28.27	.084	28.14	.084	28.01	.084	27.88	.083	27.76	.083	27.64	.083	27.53	.083
1290	30.16	.084	30.01	.084	29.85	.084	29.70	.084	29.56	.083	29.42	.084	29.28	.083	29.15	.083	29.01	.083	28.88	.083	28.75	.083	28.63	.083	28.51	.082
1300	31.20	.084	31.04	.084	30.88	.084	30.72	.083	30.57	.083	30.43	.083	30.28	.082	30.14	.082	30.00	.082	29.87	.082	29.74	.082	29.61	.082	29.49	.082
1310	32.25	.083	32.08	.083	31.92	.083	31.76	.083	31.60	.083	31.45	.083	31.30	.082	31.15	.082	31.01	.082	30.87	.082	30.74	.082	30.61	.082	30.48	.082
1320	33.28	.082	33.11	.082	32.94	.082	32.77	.082	32.61	.082	32.46	.082	32.30	.081	32.15	.081	32.00	.081	31.86	.081	31.72	.081	31.59	.081	31.46	.080
1330	34.32	.082	34.15	.082	33.97	.082	33.80	.081	33.63	.082	33.47	.081	33.31	.081	33.16	.081	33.01	.081	32.86	.081	32.72	.081	32.58	.081	32.44	.080
1340	35.37	.082	35.19	.082	35.00	.082	34.82	.081	34.65	.081	34.49	.081	34.33	.081	34.17	.081	34.01	.081	33.86	.081	33.71	.080	33.57	.080	33.43	.080
1350	36.41	.081	36.22	.081	36.03	.081	35.85	.080	35.67	.080	35.50	.080	35.33	.080	35.17	.080	35.01	.080	34.86	.080	34.71	.080	34.56	.080	34.41	.079
1360	37.45	.080	37.26	.080	37.06	.080	36.87	.079	36.69	.079	36.52	.079	36.34	.079	36.17	.079	36.01	.079	35.85	.079	35.69	.079	35.54	.079	35.39	.078
1370	38.49	.079	38.29	.079	38.09	.079	37.90	.079	37.71	.079	37.53	.079	37.35	.079	37.18	.079	37.01	.079	36.85	.079	36.69	.079	36.53	.079	36.37	.078
1380	39.53	.079	39.33	.079	39.12	.079	38.92	.078	38.73	.078	38.55	.078	38.37	.078	38.19	.078	38.01	.078	37.84	.078	37.68	.078	37.52	.078	37.36	.078
1390	40.57	.078	40.36	.078	40.15	.078	39.95	.078	39.75	.078	39.56	.078	39.37	.077	39.19	.077	39.01	.077	38.84	.077	38.67	.077	38.50	.077	38.34	.077
1400	41.61	.077	41.40	.077	41.18	.077	40.97	.077	40.77	.077	40.58	.077	40.39	.077	40.20	.077	40.01	.077	39.83	.076	39.66	.076	39.49	.076	39.33	.076
1410	42.65	.076	42.43	.076	42.21	.076	42.00	.076	41.79	.076	41.59	.076	41.39	.076	41.20	.076	41.01	.076	40.83	.076	40.65	.076	40.48	.076	40.31	.076
1420	43.69	.076	43.46	.076	43.23	.076	43.01	.076	42.80	.076	42.60	.075	42.40	.075	42.20	.075	42.01	.075	41.82	.075	41.64	.075	41.46	.075	41.28	.075
1430	44.73	.076	44.50	.076	44.27	.076	44.05	.075	43.83	.075	43.62	.075	43.41	.075	43.21	.075	43.01	.075	42.82	.075	42.63	.075	42.45	.075	42.27	.074
1440	45.78	.075	45.54	.075	45.30	.075	45.07	.074	44.85	.074	44.63	.074	44.42	.074	44.22	.074	44.02	.074	43.82	.074	43.63	.074	43.44	.074	43.25	.073
1450	46.81	.074	46.57	.073	46.32	.073	46.09	.073	45.86	.073	45.64	.073	45.43	.073	45.22	.073	45.01	.073	44.81	.073	44.62	.073	44.43	.073	44.24	.073
1460	47.86	.073	47.61	.073	47.36	.073	47.12	.073	46.89	.073	46.66	.073	46.44	.073	46.22	.073	46.01	.073	45.81	.073	45.61	.073	45.41	.073	45.22	.073
1470	48.89	.072	48.64	.072	48.39	.072	48.14	.072	47.90	.072	47.67	.072	47.45	.072	47.23	.072	47.01	.072	46.80	.072	46.60	.072	46.40	.072	46.20	.071
1480	49.93	.071	49.67	.071	49.41	.071	49.16	.071	48.92	.071	48.68	.071	48.45	.071	48.23	.071	48.01	.071	47.79	.071	47.58	.071	47.38	.071	47.18	.071
1490	50.97	.071	50.71	.071	50.45	.071	50.19	.071	49.94	.071	49.70	.071	49.47	.071	49.24	.071	49.01	.071	48.79	.071	48.58	.071	48.37	.071	48.17	.071
1500	52.02	.071	51.75	.071	51.48	.071	51.22	.071	50.97	.071	50.72	.071	50.48	.071	50.25	.071	50.02	.071	49.79	.071	49.57	.071	49.36	.071	49.16	.071

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TABLE IV-A. LOGARITHMS OF NUMBER OF CUBIC FEET OF WET PULP TO MAKE ONE TON OF DRY SLIME

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp	2.50	Correction	2.52	Correction	2.54	Correction	2.56	Correction	2.58	Correction	2.60	Correction	2.62	Correction	2.64	Correction	2.66	Correction	2.68	Correction	2.70	Correction	2.72	Correction	2.74	Correction
1010	.0170		.0149		.0124		.0103		.0081		.0060		.0039		.0022		.0000		.9981		.9963		.9944		.9926	
1020	.3181	.1033	.3160	.1028	.3137	.1023	.3113	.1017	.3092	.1012	.3073	.1008	.3051	.1003	.3032	.0999	.3010	.0994	.2991	.0989	.2973	.0985	.2953	.0981	.2936	.0977
1030	.4942	.1026	.4919	.1021	.4897	.1016	.4874	.1011	.4853	.1006	.4833	.1091	.4812	.0996	.4791	.0992	.4771	.0988	.4752	.0984	.4733	.0979	.4714	.0975	.4697	.0971
1040	.6192	.1020	.6170	.1015	.6147	.1010	.6125	.1005	.6103	.1000	.6083	.0996	.6063	.0992	.6042	.0987	.6022	.0982	.6002	.0978	.5984	.0974	.5965	.0970	.5947	.0966
1050	.7161	.1012	.7139	.1007	.7116	.1003	.7094	.0998	.7073	.0994	.7052	.0989	.7031	.0984	.7011	.0980	.6991	.0976	.6971	.0972	.6952	.0968	.6934	.0964	.6916	.0960
1060	.7953	.1006	.7931	.1001	.7908	.0996	.7886	.0991	.7865	.0967	.7844	.0983	.7823	.0979	.7803	.0974	.7783	.0970	.7763	.0967	.7745	.0963	.7726	.0959	.7708	.0955
1070	.8622	.0998	.8600	.0994	.8578	.0990	.8553	.0985	.8533	.0980	.8513	.0975	.8492	.0971	.8472	.0968	.8452	.0964	.8433	.0961	.8414	.0957	.8395	.0953	.8377	.0948
1080	.9202	.0991	.9180	.0987	.9157	.0983	.9135	.0978	.9114	.0974	.9093	.0969	.0972	.0965	.9052	.0961	.9032	.0958	.9012	.0955	.8994	.0951	.8975	.0948	.8957	.0944
1090	.9713	.0983	.9690	.0979	.9669	.0978	.9646	.0970	.9624	.0966	.9604	.0962	.9583	.0959	.9563	.0955	.9543	.0951	.9523	.0947	.9505	.0944	.9486	.0940	.9468	.0936
1100	.0170	.098	.0149	.098	.0124	.097	.0103	.097	.0081	.096	.0060	.096	.0039	.095	.0022	.095	.0000	.095	.9981	.0944	.9963	.0941	.9944	.0938	.9926	.0934
1110	.0584	.097	.0561	.096	.0539	.096	.0519	.096	.0496	.095	.0477	.095	.0457	.094	.0434	.094	.0414	.094	.0394	.093	.0378	.093	.0358	.093	.0338	.092
1120	.0962	.096	.0941	.096	.0917	.095	.0896	.095	.0874	.095	.0853	.094	.0831	.094	.0813	.093	.0792	.093	.0774	.093	.0755	.093	.0737	.093	.0719	.092
1130	.1310	.095	.1287	.095	.1265	.095	.1242	.094	.1222	.094	.1202	.093	.1179	.093	.1159	.092	.1139	.092	.1119	.092	.1103	.092	.1082	.092	.1065	.091
1140	.1632	.095	.1611	.095	.1587	.094	.1565	.094	.1544	.094	.1523	.093	.1504	.093	.1483	.092	.1461	.092	.1443	.092	.1424	.091	.1405	.091	.1386	.091
1150	.1931	.094	.1909	.094	.1886	.094	.1864	.093	.1844	.093	.1824	.092	.1801	.092	.1781	.091	.1761	.091	.1741	.091	.1723	.091	.1706	.091	.1688	.090
1160	.2212	.093	.2191	.093	.2167	.093	.2146	.092	.2122	.092	.2101	.091	.2082	.091	.2063	.091	.2041	.091	.2022	.091	.2003	.090	.1984	.089	.1967	.089
1170	.2475	.093	.2453	.092	.2430	.092	.2408	.092	.2386	.091	.2365	.091	.2345	.091	.2325	.090	.2304	.090	.2284	.089	.2266	.089	.2248	.089	.2230	.089
1180	.2723	.092	.2702	.092	.2679	.092	.2658	.092	.2634	.091	.2613	.091	.2594	.091	.2574	.091	.2555	.090	.2536	.090	.2516	.090	.2497	.089	.2480	.089
1190	.2960	.092	.2938	.092	.2914	.091	.2891	.091	.2869	.090	.2849	.090	.2829	.090	.2808	.090	.2790	.090	.2769	.089	.2751	.089	.2732	.089	.2774	.089
1200	.3181	.090	.3160	.090	.3137	.090	.3113	.090	.3092	.089	.3073	.089	.3051	.089	.3032	.088	.3010	.088	.2991	.088	.2973	.088	.2953	.087	.2936	.087
1210	.3393	.090	.3371	.090	.3349	.090	.3326	.090	.3304	.089	.3284	.089	.3263	.089	.3243	.088	.3222	.088	.3204	.088	.3185	.087	.3166	.087	.3147	.087
1220	.3595	.089	.3574	.089	.3551	.089	.3528	.089	.3506	.088	.3487	.088	.3465	.088	.3446	.087	.3424	.087	.3404	.087	.3387	.087	.3369	.087	.3351	.087
1230	.3788	.089	.3766	.089	.3744	.089	.3722	.088	.3700	.088	.3679	.087	.3659	.087	.3638	.087	.3617	.086	.3598	.086	.3579	.086	.3560	.086	.3543	.086
1240	.3972	.088	.3952	.088	.3929	.088	.3906	.087	.3885	.087	.3863	.087	.3845	.087	.3824	.086	.3802	.086	.3782	.086	.3764	.086	.3746	.086	.3727	.085
1250	.4150	.087	.4128	.087	.4104	.087	.4082	.086	.4060	.086	.4040	.086	.4021	.086	.4000	.085	.3979	.085	.3960	.085	.3943	.085	.3923	.085	.3906	.084
1260	.4322	.087	.4299	.087	.4276	.087	.4254	.087	.4232	.086	.4213	.086	.4191	.086	.4171	.086	.4151	.086	.4131	.085	.4113	.085	.4094	.085	.4076	.085
1270	.4486	.086	.4462	.086	.4440	.086	.4419	.086	.4396	.085	.4376	.085	.4355	.085	.4334	.085	.4315	.085	.4296	.084	.4276	.084	.4259	.084	.4241	.084
1280	.4643	.085	.4621	.085	.4598	.085	.4576	.084	.4555	.084	.4535	.084	.4513	.084	.4495	.084	.4473	.084	.4453	.083	.4434	.083	.4415	.083	.4398	.083
1290	.4794	.084	.4773	.084	.4749	.084	.4728	.083	.4707	.083	.4686	.083	.4666	.083	.4646	.083	.4625	.083	.4606	.083	.4586	.083	.4568	.083	.4550	.082
1300	.4942	.083	.4919	.083	.4897	.084	.4874	.083	.4853	.083	.4833	.083	.4812	.082	.4791	.082	.4771	.082	.4752	.082	.4733	.082	.4714	.082	.4697	.082
1310	.5085	.084	.5062	.084	.5041	.083	.5019	.084	.4997	.083	.4976	.084	.4955	.083	.4935	.083	.4915	.083	.4895	.082	.4877	.082	.4859	.082	.4840	.082
1320	.5222	.082	.5200	.082	.5177	.082	.5155	.081	.5134	.081	.5113	.081	.5092	.081	.5072	.081	.5051	.081	.5032	.081	.5013	.081	.4995	.081	.4978	.080
1330	.5355	.082	.5334	.082	.5311	.082	.5289	.082	.5267	.082	.5247	.082	.5226	.081	.5206	.081	.5186	.081	.5167	.081	.5148	.081	.5130	.081	.5111	.080
1340	.5486	.082	.5464	.082	.5441	.082	.5418	.081	.5397	.081	.5377	.081	.5357	.081	.5336	.081	.5316	.081	.5297	.081	.5278	.080	.5260	.080	.5241	.080
1350	.5612	.081	.5590	.081	.5567	.081	.5545	.080	.5523	.080	.5502	.080	.5481	.080	.5462	.080	.5442	.080	.5423	.080	.5404	.080	.5386	.080	.5367	.079
1360	.5734	.080	.5712	.080	.5689	.080	.5667	.079	.5645	.079	.5625	.079	.5604	.079	.5583	.079	.5564	.079	.5545	.079	.5525	.079	.5507	.079	.5489	.078
1370	.5853	.079	.5831	.079	.5808	.079	.5786	.079	.5765	.079	.5744	.079	.5723	.079	.5703	.079	.5683	.079	.5664	.079	.5645	.079	.5626	.079	.5607	.078
1380	.5969	.079	.5947	.079	.5924	.079	.5902	.078	.5880	.078	.5860	.078	.5840	.078	.5819	.078	.5799	.078	.5780	.078	.5761	.078	.5742	.078	.5724	.078
1390	.6082	.078	.6060	.078	.6037	.078	.6015	.078	.5993	.078	.5973	.078	.5952	.077	.5932	.077	.5912	.077	.5893	.077	.5874	.077	.5855	.077	.5837	.077
1400	.6192	.077	.6170	.077	.6147	.077	.6125	.077	.6103	.077	.6083	.077	.6063	.077	.6042	.077	.6022	.077	.6002	.076	.5984	.076	.5965	.076	.5947	.076
1410	.6299	.076	.6277	.076	.6254	.076	.6232	.076	.6211	.076	.6190	.076	.6169	.076	.6149	.076	.6129	.076	.6110	.076	.6091	.076	.6072	.076	.6054	.076
1420	.6404	.076	.6381	.076	.6358	.076	.6336	.075	.6314	.075	.6294	.075	.6274	.075	.6253	.075	.6234	.075	.6214	.075	.6195	.075	.6176	.075	.6157	.074
1430	.6506	.076	.6484	.076	.6461	.076	.6439	.076	.6418	.076	.6397	.076	.6376	.075	.6356	.075	.6336	.075	.6316	.075	.6297	.075	.6279	.075	.6260	.075
1440	.6607	.075	.6584	.075	.6561	.075	.6539	.074	.6518	.074	.6496	.074	.6476	.074	.6456	.074	.6436	.074	.6417	.074	.6398	.074	.6379	.074	.6360	.073
1450	.6703	.073	.6681	.073	.6658	.073	.6636	.073	.6614	.073	.6593	.073	.6573	.073	.6553	.073	.6533	.073	.6514	.073	.6495	.073	.6477	.073	.6458	.073
1460	.6800	.074	.6777	.073	.6754	.073	.6732	.073	.6711	.073	.6689	.073	.6663	.073	.6648	.073	.6628	.073	.6610	.073	.6591	.073	.6572	.073	.6553	.073
1470	.6892	.072	.6870	.072	.6848	.072	.6825	.072	.6803	.072	.6782	.072	.6762	.072	.6742	.072	.6722	.072	.6702	.072	.6684	.072	.6665	.072	.6646	.071
1480	.6984	.071	.6961	.071	.6938	.071	.6916	.071	.6895	.071	.6874	.071	.6853	.071	.6833	.071	.6813	.071	.6793	.071	.6774	.071	.6757	.071	.6738	.071
1490	.7073	.071	.7050	.071	.7029	.071	.7006	.071	.6984	.071	.6964	.071	.6943	.071	.6923	.071	.6903	.071	.6883	.071	.6865	.071	.6846	.071	.6828	.071
1500	.7162	.071	.7139	.071	.7116	.071	.7084	.071	.7073	.071	.7052	.071	.7031	.071	.7011	.071	.6991	.071	.6971	.071	.6952	.071	.6934	.071	.6916	.071

Note—The natural values are given for the corrections on account of the manner in which they are applied.

Note—The characteristics of the logarithms in the above table can be found as was done in Table 1, but it is safer with this table to look up the natural number in Table 4 and from that calculate the characteristic, which may be either 3, 2 or 1.

a constant for each value which has been calculated by assuming that between these limits the percentage line is straight. In each case the value of P has been calculated, taking d as 1 and also as 1.010. The difference between these two results, divided by 10, gives the constant used. The method of applying this correction is explained more in detail in connection with each table.

Effect of Temperature

Variations in temperature cause a change in volume of wet pulps which may give rise to a more or less serious error, the magnitude of which depends upon the temperature difference. In former articles upon the subject, the effect of temperature has been ignored. The range in temperature of pulps in cyanide practice may vary from slightly above freezing, in a cold climate, to about 50° C. (122° F.), in a tropical country, or where the solutions are heated.

After considerable investigation, we have concluded that the best method of providing for this correction is to make all calculations upon the basis of water at its greatest density (4° C.). If the specific gravity of the dry slime is determined using distilled water at 4° C. and the precaution is taken of weighing the liter of pulp at the same temperature, whatever that may be, of the large mass of pulp in the tank, in a liter flask which has been calibrated at 4° C., the effect of temperature is provided for with the exception of that due to the expansion of the flask and of the tank containing the pulp, with increasing temperature above 4° C. An ordinary glass flask[19] calibrated to contain 100 grams of water at 4° C. (39.2° F.), if used with pulps at 50° C. (122° F.) would expand about ⅛%. With average pulps this would amount to about 1½ grams per liter. The expansion of wooden tanks with increasing temperature is variable, depending upon the variety of wood[20] of which the tanks are constructed, as well as the limitation imposed by the steel hoops. The circumference of a steel tank[21] 50 ft. in diameter would be increased by about 1 in. by a rise of temperature from 4° C. to 50° C. The error due to the expansion of the liter flask is, therefore, largely compensated by the expansion of the tank containing the pulp; but even if this were not the case, this correction would be negligible.

Determination of the Specific Gravity of the Dry Slime

S (specific gravity of the dry slime) may be determined upon a sample of the dry slime by the well known pycnometer method. The pycnometer most generally used for this purpose is a small glass bottle. Into the central neck is introduced a small

[19] Calculated from data given in "Physical and Chemical Constants," by Kaye and Saby, p. 22.

[20] Ibid., p. 53.

[21] Ibid., p. 53.

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glass thermometer, through the medium of a ground joint, for the purpose of indicating the temperature. Similarly, into the other neck is fitted a glass stopper, having a capillary opening at the center.

Clean the pycnometer and fill with recently boiled distilled water at 4° C. so that the water just overflows the capillary opening in the glass stopper. Dry the outside and weigh accurately. Call this weight "D." Fill the pycnometer about half full of distilled water, then introduce five grams of the dry slime, which has been accurately weighed. Boil to remove air, cool on ice to 4° C., add water at 4° C. to fill the flask, and weigh. Call this weight C. Call the weight of the ore taken W. Specific gravity of the dry slime $= \frac{W}{D + W - C}$. By taking a greater weight of the dry slime, this determination can be made in the ordinary 1000-c.c. flask, and it is perhaps desirable to use the larger flask when an accurate analytical balance is not available.

This is sometimes termed the specific gravity of the wet pulp, but the weight of a liter of the wet pulp, expressed in grams, appears to be a better term, therefore we have designated it in this manner throughout the tables. This is determined by weighing 1000 c.c. of the wet pulp at the temperature of the large mass of pulp. Sharwood[22] prefers a conical vessel made of tin plate for making this determination in mill work. Stadler[23] states that in practice he has found that a flask (presumably glass) having a large mouth ground true, the ground edge to be used as a mark of capacity, is more convenient than the usual flask with a mark below the mouth. Pooler[24] admits the convenience of the large neck flask as advocated by Stadler, but calls attention to the great error which may arise when it is used. For various reasons we favor for this purpose in both laboratory and mill work the use of the ordinary 1000-c.c. narrow-neck flask cut off about ½ in. above the mark. The narrow neck projecting a short distance above the mark makes for greater accuracy and on account of the care necessary in handling a flask completely filled with solution or pulp is fully as convenient to use as the wide-neck flask which is filled level full. The frequent breaking of the glass flask, due to the rough handling which such apparatus receives in mill work, cannot be denied; but herein lies one of its strong points of advantage. A thin metal flask may soon become inaccurate through distortion and denting; but as long as it does not leak, the mill man is prone to continue its use. When such an accident happens to a glass flask, it is put entirely out

22"Measurement of Pulp and Tailing," "Min. Mag.," Vol. 1, p. 304.

23"Practical Applications of the Specific Gravity or Moisture Flask," "Journ." Chem., Met. and Min. Soc. S. A., Vol. 12, p. 167.

24"Discussion of Practical Application of the Specific Gravity or Moisture Flask," "Journ." Chem., Met. and Min. Soc. S. A., Vol. 12, p. 170.

TABLE IV. NUMBER OF CUBIC FEET OF WET PULP TO MAKE ONE TON OF DRY SLIME—Continued

Formula: $\frac{2000}{64.42\ a\ \frac{P}{100}}$

Specific Gravity of Dry Slime

2.76	Correction	2.78	Correction	2.80	Correction	2.82	Correction	2.84	Correction	2.86	Correction	2.88	Correction	2.90	Correction	2.92	Correction	2.94	Correction	2.96	Correction	2.98	Correction	3.00	Correction	
2043		2052		2060		2068		2076		2084		2092		2099		2107		2115		2122		2129		2136		1010
1022	100.9	1026	101.4	1030	101.8	1034	102.3	1038	102.7	1042	103.1	1046	103.5	1050	103.9	1053	104.3	1057	104.7	1061	105.0	1065	105.5	1068	105.8	1020
681.1	33.5	683.9	33.6	686.7	33.7	689.4	33.9	692.0	34.1	694.6	34.2	697.2	34.3	699.8	34.4	702.3	34.5	704.8	34.7	707.3	34.8	709.7	34.9	712.0	35.1	1030
510.7	16.65	512.8	16.72	514.9	16.79	516.9	16.87	518.9	16.94	520.9	17.00	522.9	17.07	524.8	17.14	526.7	17.21	528.6	17.27	530.4	17.33	532.2	17.39	534.0	17.46	1040
408.6	9.92	410.3	9.97	411.9	10.02	413.5	10.07	415.1	10.11	416.7	10.14	418.3	10.18	419.9	10.22	421.4	10.26	422.9	10.30	424.4	10.34	425.8	10.38	427.2	10.42	1050
340.5	6.58	341.9	6.61	343.2	6.64	344.6	6.67	345.9	6.70	347.2	6.73	348.6	6.75	349.9	6.77	351.1	6.80	352.4	6.83	353.6	6.86	354.8	6.88	356.0	6.91	1060
291.9	4.66	293.1	4.68	294.3	4.70	295.5	4.72	296.6	4.75	297.7	4.77	298.8	4.79	299.9	4.81	301.0	4.83	302.1	4.85	303.1	4.87	304.2	4.88	305.2	4.90	1070
255.4	3.48	256.4	3.50	257.5	3.51	258.5	3.53	259.5	3.55	260.5	3.56	261.5	3.58	262.4	3.59	263.3	3.61	264.3	3.62	265.2	3.64	266.1	3.65	267.0	3.67	1080
227.0	2.69	228.0	2.70	228.9	2.71	229.8	2.72	230.7	2.74	231.5	2.76	232.4	2.77	233.3	2.78	234.1	2.79	235.0	2.80	235.8	2.81	236.6	2.82	237.4	2.83	1090
204.3	2.14	205.2	2.15	206.0	2.16	206.8	2.17	207.6	2.18	208.4	2.19	209.2	2.20	209.9	2.21	210.7	2.22	211.4	2.23	212.2	2.24	212.9	2.25	213.6	2.26	1100
185.7	1.74	186.5	1.75	187.2	1.76	188.0	1.77	188.7	1.78	189.4	1.79	190.2	1.79	190.9	1.80	191.5	1.81	192.2	1.82	192.9	1.82	193.6	1.82	194.2	1.83	1110
170.3	1.44	171.0	1.45	171.6	1.46	172.3	1.47	172.9	1.48	173.6	1.48	174.3	1.48	174.9	1.49	175.6	1.49	176.2	1.50	176.8	1.51	177.4	1.52	178.0	1.52	1120
157.2	1.21	157.8	1.21	158.5	1.22	159.1	1.23	159.7	1.24	160.3	1.24	160.9	1.24	161.5	1.25	162.1	1.25	162.7	1.26	163.2	1.26	163.8	1.27	164.3	1.28	1130
145.9	1.04	146.5	1.04	147.1	1.05	147.7	1.05	148.3	1.06	148.8	1.06	149.4	1.06	150.0	1.07	150.5	1.07	151.0	1.08	151.6	1.08	152.1	1.09	152.6	1.09	1140
136.2	.89	136.7	.90	137.3	.90	137.9	.90	138.4	.91	138.9	.91	139.4	.92	139.9	.93	140.4	.93	140.9	.94	141.4	.94	141.9	.94	142.4	.94	1150
127.7	.77	128.2	.78	128.7	.79	129.2	.79	129.7	.80	130.2	.80	130.7	.80	131.2	.80	131.7	.80	132.1	.81	132.6	.81	133.1	.81	133.5	.82	1160
120.2	.68	120.7	.68	121.2	.68	121.7	.69	122.1	.69	122.6	.69	123.1	.70	123.5	.70	123.9	.70	124.4	.71	124.8	.71	125.3	.71	125.7	.72	1170
113.5	.60	114.0	.60	114.4	.61	114.9	.61	115.3	.62	115.7	.62	116.2	.62	116.6	.63	117.0	.63	117.5	.63	117.9	.63	118.3	.63	118.7	.64	1180
107.5	.54	108.0	.54	108.4	.54	108.8	.54	109.2	.55	109.6	.55	110.1	.55	110.5	.55	110.9	.55	111.3	.56	111.7	.56	112.0	.57	112.4	.57	1190
102.2	.47	102.6	.48	103.0	.48	103.4	.48	103.8	.49	104.2	.49	104.6	.49	105.0	.49	105.3	.49	105.7	.50	106.1	.50	106.5	.50	106.8	.51	1200
97.29	.43	97.70	.43	98.10	.43	98.49	.43	98.87	.44	99.24	.44	99.61	.44	99.98	.44	100.3	.44	100.7	.45	101.0	.45	101.4	.45	101.7	.46	1210
92.87	.387	93.26	.389	93.64	.391	94.01	.393	94.37	.395	94.73	.397	95.08	.399	95.43	.401	95.77	.403	96.11	.41	96.45	.41	96.78	.41	97.10	.41	1220
88.83	.351	89.20	.353	89.56	.355	89.92	.357	90.27	.359	90.61	.361	90.95	.363	91.28	.365	91.61	.367	91.94	.369	92.26	.371	92.57	.373	92.88	.375	1230
85.13	.320	85.48	.322	85.83	.324	86.17	.326	86.50	.328	86.82	.330	87.15	.332	87.47	.333	87.79	.335	88.10	.337	88.41	.339	88.71	.341	89.00	.343	1240
81.73	.291	82.07	.293	82.40	.295	82.73	.297	83.05	.299	83.36	.300	83.67	.302	83.98	.304	84.28	.306	84.58	.308	84.88	.309	85.17	.310	85.45	.312	1250
78.57	.269	78.90	.271	79.22	.273	79.54	.274	79.84	.276	80.13	.278	80.44	.279	80.74	.281	81.02	.282	81.32	.284	81.60	.285	81.88	.286	82.15	.287	1260
75.67	.247	75.98	.249	76.28	.251	76.58	.252	76.88	.254	77.16	.255	77.46	.256	77.75	.257	78.02	.259	78.31	.260	78.58	.261	78.85	.262	79.10	.263	1270
72.95	.228	73.26	.229	73.56	.230	73.85	.232	74.13	.233	74.41	.234	74.69	.236	74.96	.237	75.23	.238	75.50	.239	75.77	.241	76.03	.242	76.28	.243	1280
70.45	.210	70.74	.211	71.02	.213	71.31	.214	71.58	.215	71.85	.216	72.12	.217	72.38	.218	72.64	.219	72.91	.221	73.17	.222	73.42	.223	73.66	.224	1290
68.11	.195	68.39	.196	68.66	.197	68.94	.199	69.20	.200	69.46	.201	69.73	.202	69.98	.203	70.23	.204	70.48	.206	70.73	.207	70.97	.208	71.20	.209	1300
65.90	.182	66.17	.183	66.44	.184	66.71	.186	66.96	.187	67.21	.188	67.46	.189	67.71	.190	67.95	.191	68.20	.192	68.44	.193	68.67	.194	68.90	.195	1310
63.85	.167	64.12	.168	64.38	.169	64.64	.171	64.88	.172	65.12	.173	65.37	.174	65.61	.175	65.84	.176	66.08	.177	66.31	.178	66.54	.179	66.76	.180	1320
61.91	.158	62.17	.159	62.42	.160	62.67	.161	62.91	.162	63.14	.163	63.39	.164	63.62	.165	63.84	.166	64.08	.167	64.30	.168	64.52	.169	64.73	.170	1330
60.09	.147	60.34	.148	60.58	.149	60.83	.150	61.05	.151	61.28	.152	61.51	.152	61.74	.153	61.96	.154	62.19	.155	62.41	.156	62.62	.157	62.82	.158	1340
58.37	.137	58.61	.138	58.85	.139	59.09	.140	59.31	.141	59.53	.142	59.76	.142	59.98	.143	60.19	.144	60.41	.145	60.62	.146	60.83	.147	61.02	.148	1350
56.75	.128	56.99	.129	57.22	.130	57.45	.131	57.66	.132	57.88	.133	58 10	.133	58.31	.134	58.52	.135	58.73	.136	58.94	.137	59.14	.138	59.33	.139	1360
55.22	.122	55.45	.123	55.67	.123	55.89	.124	56.11	.125	56.31	.126	56.53	.127	56.73	.128	56.93	.128	57.14	.129	57.34	.129	57.54	.130	57.73	.130	1370
53.76	.114	53.99	.115	54.20	.116	54.42	.116	54.63	.117	54 83	.118	55.04	.119	55.24	.120	55.44	.120	55.64	.121	55.83	.122	56.02	.123	56.21	.123	1380
52.38	.108	52.60	.109	52.81	.109	53.02	.110	53.22	.111	53.42	.111	53.63	.112	53.83	.113	54.02	.113	54.21	.114	54.40	.114	54.59	.115	54.77	.115	1390
51.07	.102	51.29	.103	51.49	.103	51.70	.104	51.89	.105	52.08	.105	52.28	.106	52.48	.107	52 66	.107	52.86	.108	53.04	.108	53.22	.109	53.40	.109	1400
49.83	.095	50.04	.096	50.24	.096	50.44	.097	50.63	.098	50.82	.098	51.01	.099	51.20	.100	51.38	.100	51.57	.101	51.75	.101	51.93	.102	52.10	.102	1410
48.65	.090	48.85	.091	49.05	.091	49.25	.092	49 43	.093	49.61	.093	49 81	.094	49.99	.095	50.16	.095	50.34	.096	50.52	.096	50.70	.097	50.87	.097	1420
47.51	.086	47.71	.087	47.90	.087	48.10	.088	48.29	.089	48.46	.089	48.64	.090	48.82	.091	48.99	.091	49.17	.092	49.34	.092	49.51	.093	49.67	.093	1430
46.43	.081	46.62	.082	46.81	.082	47.00	.083	47.18	.084	47.35	.084	47.53	.085	47.70	.086	47.87	.086	48.05	.087	48.22	.087	48 38	.088	48.54	.088	1440
45.40	.075	45.59	.076	45.78	.077	45.96	.078	46.13	.079	46.30	.079	46.48	.080	46 65	.081	46.81	.081	46.98	.082	47.15	.082	47.31	.083	47.47	.083	1450
44.41	.074	44.59	.074	44.77	.075	44.95	.075	45.12	.076	45.29	.077	45.46	.077	45.63	.078	45 79	.078	45.96	.079	46.12	.079	46.28	.080	46.43	.080	1460
43.47	.069	43.65	.069	43.82	.070	44.00	.071	44.17	.071	44.33	.072	44.50	.072	44.66	.073	44.82	.073	44.98	.074	45.14	074	45.30	.075	45.45	.075	1470
42.57	.066	42.75	.066	42 91	.067	43.09	.067	43.25	.068	43.41	.069	43.58	.069	43.74	.070	43.89	.070	44.06	.070	44.21	.071	44.36	.071	44.50	.071	1480
41.70	.064	41.87	.065	42.03	.065	42.21	.065	42.36	.066	42.52	.066	42.69	.066	42.84	.067	42.99	.067	43.15	.067	43.30	.069	43.45	.069	43.59	.069	1490
40.86	.060	41.03	.060	41.19	.061	41.36	.061	41 52	.062	41.67	.062	41.83	.062	41.99	.063	12.14	.063	42.20	.064	42.43	.064	42.58	.065	42.72	.066	1500

Weight in Grams of One Liter of Wet Pulp

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TABLE IV-A. LOGARITHMS OF NUMBER OF CUBIC FEET OF WET PULP TO MAKE ONE TON OF DRY SLIME—Continued

Specific Gravity of Dry Slime

2.76	Correction	2.78	Correction	2.80	Correction	2.82	Correction	2.84	Correction	2.86	Correction	2.88	Correction	2.90	Correction	2.92	Correction	2.94	Correction	2.96	Correction	2.98	Correction	3.00	Correction	
.3103		.3122		.3139		.3156		.3172		.3189		.3206		.3220		.3237		.3253		.3267		.3282		.3296		1010
.0094	100.9	.0111	101.4	0128	101.8	.0145	102.3	.0162	102.7	.0179	103.1	0195	103.5	0212	103.9	.0224	104.3	.0241	104.7	.0257	105.0	.0273	105.4	0286	105.8	1020
.8332	33.5	.8350	33.6	.8367	33.7	.8385	33.9	.8401	34.1	.8417	34.2	.8434	34.3	8450	34.4	.8465	34.5	.8481	34.7	.8496	34.8	.8511	34.9	.8525	35.1	1030
.7082	16.65	.7100	16.72	.7117	16.79	.7134	16.87	.7151	16.94	.7168	17.00	.7184	17.07	.7200	17.14	.7216	17.21	.7231	17.27	.7246	17.33	.7261	17.39	.7275	17.46	1040
.6113	9.92	.6131	9.97	.6148	10.02	.6165	10.07	.6182	10.11	.6198	10.14	.6215	10.18	.6231	10.22	.6247	10.26	.6262	10.30	.6278	10.34	.6292	10.38	.6306	10.42	1050
.5321	6.58	.5339	6.61	.5355	6.64	.5373	6.67	.5390	6.70	.5406	6.73	.5423	6.75	.5439	6.77	.5454	6.80	.5470	6.83	.5485	6.86	.5500	6.88	.5514	6.91	1060
.4652	4.66	.4670	4.68	.4688	4.70	.4706	4.72	.4722	4.75	.4738	4.77	.4754	4.79	.4770	4.81	.4786	4.83	.4802	4.85	.4816	4.87	.4832	4.88	.4846	4.90	1070
.4072	3.48	.4089	3.50	.4108	3.51	.4125	3.53	.4141	3.55	.4158	3.56	.4175	3.58	.4190	3.59	.4205	3.61	.4221	3.62	.4236	3.64	.4250	3.65	.4265	3.67	1080
.3560	2.69	.3579	2.70	.3596	2.71	.3614	2.72	.3630	2.74	.3646	2.76	.3662	2.77	.3679	2.78	.3694	2.79	.3711	2.80	.3725	2.81	.3740	2.82	.3755	2.83	1090
.3103	2.14	.3122	2.15	.3139	2.16	.3156	2.17	.3172	2.18	.3189	2.19	.3306	2.20	.3220	2.21	.3237	2.22	.3251	2.23	.3267	2.24	.3282	2.25	.3296	2.26	1100
.2688	1.74	.2707	1.75	.2723	1.76	.2742	1.77	.2758	1.78	.2774	1.79	.2792	1.79	.2808	1.80	.2822	1.81	.2838	1.82	.2853	1.82	.2869	1.82	.2882	1.83	1110
.2312	1.44	.2330	1.45	.2345	1.46	.2363	1.47	.2378	1.48	.2395	1.48	.2413	1.49	.2428	1.49	.2445	1.49	.2460	1.50	.2475	1.51	.2491	1.52	.2504	1.52	1120
.1965	1.21	.1981	1.21	.2000	1.22	.2017	1.23	.2033	1.24	.2049	1.24	.2066	1.24	.2082	1.25	.2098	1.25	.2114	1.26	.2127	1.26	.2143	1.29	.2156	1.28	1130
.1641	1.04	.1658	1.04	.1676	1.05	.1694	1.05	.1711	1.06	.1726	1.06	1744	1.06	.1761	1.07	.1775	1.07	.1790	1.08	.1807	1.08	.1821	1.09	.1836	1.09	1140
.1342	.89	.1358	.90	.1377	.90	1396	.90	.1411	.91	.1427	.91	.1443	.92	.1458	.93	.1474	.93	.1480	.94	.1504	.94	.1520	.94	.1535	.94	1150
.1062	.77	.1079	.78	.1096	.79	.1113	.79	.1129	.80	.1146	.80	.1163	.80	.1179	.80	.1196	.80	.1209	.81	.1225	.81	.1242	.81	.1255	.82	1160
.0799	.68	.0817	.68	.0835	.68	.0853	.69	.0867	.69	.0885	.69	.0903	.70	.0917	.70	.0931	.70	.0948	.71	.0962	.71	.0980	.71	.0993	.72	1170
.0550	.60	.0569	.60	.0584	.61	.0603	.61	.0618	.62	.0633	.62	.0652	.62	.0667	.63	.0682	.63	.0700	.63	.0715	.63	.0730	.63	.0745	.64	1180
.0314	.54	.0334	.54	.0350	.54	.0366	.54	.0382	.55	.0398	.55	.0418	.55	.0434	.55	.0449	.55	.0465	.56	.0481	.56	.0492	.57	.0508	.57	1190
.0095	.47	.0111	.48	.0128	.48	.0145	.48	.0162	.49	.0179	.49	.0195	.49	.0212	.49	.0224	.49	.0241	.50	.0257	.50	.0273	.50	.0286	.51	1200
.9881	.43	.9899	.43	.9917	.43	.9934	.43	.9951	.44	.9967	.44	.9983	.44	.9999	.44	.0013	.44	.0030	.45	.0043	.45	.0060	.45	.0073	.46	1210
.9679	.387	.9697	.389	.9715	.391	.9732	.393	.9748	.395	.9765	.397	.9781	.399	.9797	.401	.9812	.403	.9828	.41	.9843	.41	.9858	.41	.9872	.41	1220
.9486	.351	.9504	.353	.9521	.355	.9539	.357	.9555	.359	.9572	.361	.9588	.363	.9604	.365	.9619	.367	.9635	.369	.9650	.371	.9665	.373	.9679	.375	1230
.9301	.320	.9319	.322	.9336	.324	.9354	.326	.9370	.328	.9386	.330	.9403	.332	.9419	.333	.9434	.335	.9450	.337	.9465	.339	.9480	.341	.9494	.343	1240
.9124	.291	.9142	.293	.9159	.295	.9177	.297	.9193	.299	.9210	.300	.9226	.302	.9242	.304	.9257	.306	.9273	.308	.9288	.309	.9303	.310	.9317	.312	1250
.8953	.269	.8971	.271	.8988	.273	.9006	.274	.9022	.276	.9038	.278	.9055	.279	.9071	.281	.9086	.282	.9102	.284	.9117	.285	.9132	.286	.9146	.287	1260
.8789	.247	.8807	.249	.8824	.251	.8841	.252	.8858	.254	.8874	.255	.8891	.256	.8907	.257	.8922	.259	.8938	.260	.8953	.261	.8968	.262	.8982	.263	1270
.8630	.228	.8649	.229	.8666	.230	.8684	.232	.8700	.233	.8716	.234	.8733	.236	.8748	.237	.8764	.238	.8779	.239	.8795	.241	.8810	.242	.8824	.243	1280
.8479	.210	.8497	.211	.8514	.213	.8532	.214	8548	.215	.8564	.216	.8581	.217	.8596	.218	.8612	.219	.8628	.221	.8643	.222	.8658	.223	.8672	.224	1890
.8332	.195	.8350	.196	.8367	.197	.8385	.199	.8401	.200	.8417	.201	.8434	.202	.8450	.203	.8465	.204	.8481	.206	.8496	.207	.8511	.208	.8525	.209	1300
.8189	.182	.8207	.183	.8224	.184	.8242	.186	.8258	.187	.8274	.188	.8290	.189	.8307	.190	.8322	.191	.8338	.192	.8353	.193	.8368	.194	.8382	.195	1310
.8052	.167	.8070	.168	.8088	.169	.8105	.171	.8121	.172	.8137	.173	.8154	.174	.8170	.175	.8185	.176	.8201	.177	.8216	.178	.8231	.179	.8245	.180	1320
.7919	.158	.7936	.159	.7953	.160	.7971	.161	.7987	.162	.8003	.163	.8020	.164	.8036	.165	.8051	.166	.8067	.167	.8082	.168	.8097	.169	.8111	.170	1330
.7788	.147	.7806	.148	.7823	.149	.7841	.150	.7857	.151	.7873	.152	.7889	.152	.7906	.153	.7924	.154	.7977	.155	.7952	.156	.7967	.157	.7981	.158	1340
.7662	.137	.7680	.138	.7697	.139	.7715	.140	.7731	.141	.7747	.142	.7764	.142	.7780	.143	.7795	.144	.7811	.145	.7826	.146	.7841	.147	.7855	.148	1350
.7540	.128	.7558	.129	.7575	.130	.7593	.131	.7609	.132	.7625	.133	.7642	.133	.7657	.134	.7673	.135	.7689	.136	.7704	.137	.7719	.138	.7733	.139	1360
.7421	.122	.7439	.123	.7456	.123	.7473	.124	.7490	.125	.7506	.126	.7523	.127	.7538	.128	.7553	.128	.7569	.129	.7585	.129	.7600	.130	.7614	.130	1370
.7305	.114	.7323	.115	.7340	.116	.7358	.116	.7374	.117	.7390	.118	.7407	.119	.7422	.120	.7438	.120	.7454	.121	.7469	.122	.7483	.123	.7498	.123	1380
.7192	.108	.7210	.109	.7227	.109	.7244	.110	.7261	.111	.7277	.111	.7294	.112	.7310	.113	.7326	.113	.7341	.114	.7356	.114	.7371	.115	.7385	.115	1390
.7082	.102	.7100	.103	.7117	.103	.7135	.104	.7151	.105	.7167	.105	.7183	.106	.7200	.107	.7215	.107	.7231	.108	.7246	.108	.7261	.109	.7275	.109	1400
.6975	.095	.6993	.096	.7010	.096	.7028	.097	.7044	.098	.7060	.098	.7077	.099	.7093	.100	.7108	.100	.7124	.101	.7139	.101	.7154	.102	.7168	.102	1410
.6871	.090	.6889	.091	.6906	.091	.6924	.092	.6940	.093	.6956	.093	.6973	.094	.6989	.095	.7004	.095	.7020	.096	.7035	.096	.7050	.097	.7065	.097	1420
.6768	.086	.6786	.087	.6803	.087	.6821	.088	.6839	.089	.6854	.089	.6870	.090	6886	.091	.6901	.091	.6917	.092	.6932	.092	.6947	.093	.6961	.093	1430
.6668	.081	.6686	.082	.6703	.082	.6721	.083	.6738	.084	.6753	.084	.6770	.085	.6785	.086	.6801	.086	.6817	.087	.6832	.087	.6847	.088	.6861	.088	1440
.6571	.075	.6589	.076	.6607	.077	.6624	.078	.6640	.079	.6656	.079	.6673	.080	.6689	.081	.6703	.081	.6719	.082	.6735	.082	.6750	.083	.6764	.083	1450
.6475	.074	.6493	.074	.6510	.075	.6527	.075	.6544	.076	.6560	.077	.6576	.077	.6592	.078	.6608	.078	.6624	.079	.6639	.079	.6654	.080	.6668	.080	1460
.6382	.069	.6400	.069	.6417	.070	.6434	.071	.6451	.071	.6467	.072	.6484	.072	.6499	.073	.6515	.073	.6530	.074	.6546	.074	.6561	.075	.6575	.075	1470
.6291	.066	.6309	.066	.6326	.067	.6344	.067	.6360	.068	.6376	.069	.6393	.069	.6409	.070	.6424	.070	.6440	.070	.6455	.071	.6470	.071	.6484	.071	1480
.6201	.064	.6219	.065	.6236	.065	.6254	.065	.6270	.066	.6286	.066	.6303	.066	.6318	.067	.6334	.067	.6350	.067	.6365	.069	.6380	.069	.6394	.069	1490
.6113	.060	.6131	.060	.6148	.061	.6166	.061	.6183	.062	.6198	.062	.6215	.062	.6251	.063	.6247	.063	.6262	.064	.6277	.064	.6292	.065	.6306	.066	1500

Weight in Grams of One Liter of Wet Pulp

Note—The characteristics of these logarithms are best found by looking at the natural numbers corresponding to them, and calculating from the numbers, as in ordinary logarithmic work. They are 3, 2 or 1, and the change is apparent from the change in mantissa, so that after experience with the table, they can be determined by inspection.

of service. Another source of error in both glass and metal flasks is the coating of lime and slime which tends to build up upon the inside of the flask. A glass flask can be readily cleaned with acid, while a metal flask is not so readily cleaned.

The ordinary 1000-c.c. flask, as received from the dealer, should be calibrated by weighing in it exactly 1000 grams of distilled water at 4° C. Mark the level of the bottom of the meniscus by means of a file on the neck of the flask, and as has been previously mentioned, it is an advantage to cut off the neck about ½ in. above the mark. The flask should always be thoroughly cleaned before being used.

Care must be taken in obtaining the sample of pulp for this determination to insure that it is truly representative of the whole mass in the tank. The sample is perhaps best taken as suggested by Caldecott[25] by using a vessel having a small opening, so that the pulp can be taken at different depths in the tank. The pulp should be in violent agitation when the sample is taken. Thoroughly mix the pulp by stirring before filling the flask. After wiping out the inside of the neck of the flask above the pulp with a clean rag or piece of filter paper, weigh in grams upon a large pulp balance and deduct the weight of the flask. Example: If the net weight of 1000 c.c. of the pulp is 1235.6 grams, the specific gravity is 1.2356.

[25] "Slime Pulp Formulas," W. A. Caldecott. Proc. Chem. and Met. Soc. S. A., Vol. 2, p. 837.

The weight of a liter of pulp expressed in grams is used in connection with the various tables; but if this value is substituted in formulas in which the specific gravity of the dry slime and of the solution appear, it must be expressed as specific gravity.

The hydrometer does not ordinarily give satisfactory results when used for determining the specific gravity of slime pulp, but there is a special type which we have not had the opportunity of investigating, which, with certain modifications, appears to be capable of giving good results.

Fill the 1000-c.c. flask (calibrated at 4° C.) with clear solution which has been cooled to 4°. Weigh the flask in grams and point off three places to give specific gravity. Example: If the net weight of the solution is 1008 grams, the specific gravity is 1.008.

Accuracy of Specific-Gravity Method of Determining Tonnage

The accuracy of the specific-gravity method of determining tonnage when used over a sufficiently long period of time seems to be pretty well established. Slight errors in the determinations and calculations are largely compensating when a large number of slime charges are involved, for they do not occur in the same direction. However, there are other errors which apparently are unimportant because of the slight effect upon individual charges which become of importance when a large number

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of charge are involved, on account of occurring in one direction; thus disregard of the specific gravity of the solution might in certain cases cause an important effect upon a year's tonnage. Stadler[26] states that at the Knight Gold Mining Co.'s cyanide plant the daily tonnage measurements of the mill pulp for several years have been regularly taken by the specific-gravity method, which after careful investigation was found to give most reliable results. Johnston[27] states that the tonnage treated at the Nipissing low-grade mill, as determined by weighing with a Fairbanks registering scale, mak-

[26] "Practical Applications of the Specific Gravity or Moisture Flask," "Journ." Chem., Met. and Min. Soc. S. A., Vol. 12, p. 168.
[27] "The Mill and Metallurgical Practice of the Nipissing Mining Co., Ltd., Cobalt, Ont., Canada," Bull. A. I. M. E., Jan., 1914, p. 122.

TABLE V. DILUTION—RATIO OF SOLUTION TO DRY SLIME

Formula: $$\frac{64.42\,a - 64.42\,a\frac{P}{100}}{64.42\,a - \frac{P}{100}}$$

Specific Gravity of Dry Slime

Weight in Grams of One Liter of Wet Pulp	2.50	2.52	2.54	2.56	2.58	2.60	2.62	2.64	2.66	2.68	2.70	2.72	2.74	2.76	2.78	2.80	2.82	2.84	2.86	2.88	2.90	2.92	2.94	2.96	2.98	3.00
1010	59.6	60.0	60.3	60.6	60.9	61.2	61.5	61.8	62.0	62.3	62.6	62.9	63.2	63.5	63.7	63.9	64.2	64.4	64.7	65.0	65.3	65.5	65.7	66.0	66.2	66.4
1020	29.6	29.8	29.9	30.1	30.2	30.4	30.5	30.7	30.8	31.0	31.1	31.3	31.4	41.5	31.6	31.8	31.9	32.0	32.2	32.3	32.4	32.5	32.6	32.8	32.9	33.0
1030	19.6	19.7	19.8	19.9	20.0	20.1	20.2	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.0	21.1	21.2	21.3	21.4	21.5	21.5	21.6	21.7	21.8	21.9
1040	14.6	14.7	14.8	14.8	14.9	15.0	15.0	15.1	15.2	15.3	15.4	15.4	15.5	15.6	15.6	15.7	15.8	15.8	15.9	15.9	16.0	16.1	16.1	16.2	16.3	16.3
1050	11.6	11.7	11.8	11.8	11.9	11.9	12.0	12.0	12.1	12.1	12.2	12.3	12.3	12.4	12.4	12.5	12.6	12.6	12.7	12.7	12.8	12.8	12.9	12.9	13.0	13.0
1060	9.60	9.67	9.72	9.77	9.82	9.87	9.92	9.97	10.0	10.1	10.1	10.2	10.2	10.3	10.3	10.4	10.4	10.5	10.5	10.5	10.6	10.6	10.7	10.7	10.8	10.8
1070	8.18	8.23	8.27	8.32	8.37	8.41	8.45	8.50	8.54	8.58	8.62	8.66	8.71	8.75	8.79	8.83	8.87	8.90	8.94	8.98	9.01	9.05	9.08	9.12	9.16	9.19
1080	7.10	7.14	7.18	7.22	7.26	7.30	7.34	7.38	7.42	7.46	7.49	7.53	7.57	7.61	7.64	7.68	7.71	7.75	7.78	7.81	7.85	7.88	7.91	7.94	7.97	8.00
1090	6.27	6.31	6.34	6.38	6.42	6.46	6.49	6.53	6.56	6.60	6.63	6.66	6.69	6.76	6.76	6.79	6.82	6.85	6.88	6.91	6.94	6.97	7.00	7.03	7.05	7.08
1100	5.55	5.60	5.65	5.70	5.74	5.77	5.81	5.84	5.87	5.90	5.93	5.96	5.99	6.02	6.04	6.07	6.10	6.13	6.16	6.18	6.21	6.23	6.26	6.28	6.31	6.34
1110	5.05	5.09	5.12	5.16	5.19	5.22	5.25	5.28	5.30	5.33	5.36	5.38	5.41	5.44	5.47	5.49	5.52	5.54	5.57	5.60	5.62	5.64	5.66	5.68	5.70	5.72
1120	4.59	4.62	4.65	4.68	4.71	4.74	4.77	4.80	4.83	4.86	4.88	4.91	4.93	4.96	4.99	5.01	5.03	5.06	5.08	5.10	5.12	5.14	5.16	5.18	5.20	5.22
1130	4.22	4.25	4.28	4.30	4.33	4.35	4.38	4.40	4.43	4.45	4.47	4.49	4.52	4.55	4.57	4.59	4.61	4.63	4.65	4.67	4.70	4.72	4.74	4.76	4.78	4.80
1140	3.89	3.91	3.94	3.96	3.99	4.01	4.04	4.06	4.09	4.11	4.13	4.16	4.18	4.20	4.22	4.24	4.26	4.28	4.30	4.32	4.34	4.36	4.38	4.40	4.41	4.42
1150	3.60	3.63	3.66	3.68	3.70	3.72	3.74	3.76	3.79	3.81	3.83	3.85	3.87	3.89	3.91	3.93	3.95	3.97	3.99	4.01	4.02	4.04	4.05	4.07	4.09	4.11
1160	3.34	3.37	3.40	3.42	3.44	3.46	3.48	3.50	3.52	3.54	3.56	3.58	3.60	3.62	3.64	3.66	3.68	3.70	3.72	3.73	3.75	3.77	3.79	3.80	3.81	3.83
1170	3.13	3.15	3.18	3.20	3.22	3.24	3.26	3.28	3.30	3.32	3.33	3.35	3.37	3.39	3.40	3.42	3.44	3.46	3.48	3.49	3.51	3.53	3.54	3.56	3.58	3.59
1180	2.93	2.95	2.97	2.99	3.01	3.03	3.05	3.07	3.09	3.11	3.13	3.14	3.16	3.18	3.20	3.22	3.23	3.25	3.26	3.27	3.29	3.31	3.33	3.34	3.36	3.37
1190	2.75	2.77	2.79	2.81	2.83	2.85	2.87	2.89	2.91	2.93	2.94	2.96	2.98	3.00	3.01	3.03	3.04	3.06	3.07	3.08	3.10	3.11	3.13	3.14	3.16	3.17
1200	2.60	2.62	2.64	2.66	2.68	2.70	2.72	2.73	2.75	2.77	2.78	2.80	2.81	2.83	2.84	2.86	2.87	2.89	2.90	2.92	2.93	2.95	2.96	2.98	2.99	3.00
1210	2.46	2.48	2.50	2.51	2.53	2.54	2.56	2.58	2.60	2.61	2.63	2.64	2.66	2.67	2.69	2.70	2.72	2.73	2.75	2.76	2.78	2.80	2.81	2.83	2.85	2.86
1220	2.32	2.34	2.36	2.37	2.39	2.41	2.43	2.44	2.46	2.47	2.49	2.50	2.52	2.53	2.55	2.56	2.58	2.59	2.61	2.62	2.64	2.65	2.66	2.67	2.68	2.69
1230	2.21	2.23	2.24	2.26	2.27	2.29	2.30	2.32	2.33	2.35	2.37	2.38	2.39	2.41	2.42	2.43	2.45	2.46	2.47	2.49	2.50	2.51	2.53	2.54	2.55	2.57
1240	2.09	2.11	2.13	2.14	2.16	2.17	2.19	2.21	2.22	2.24	2.25	2.27	2.28	2.29	2.30	2.31	2.33	2.34	2.35	2.37	2.38	2.39	2.40	2.42	2.43	2.44
1250	2.00	2.01	2.03	2.05	2.06	2.08	2.09	2.11	2.12	2.14	2.15	2.17	2.18	2.20	2.21	2.22	2.23	2.24	2.25	2.26	2.27	2.29	2.30	2.31	2.32	2.33
1260	1.91	1.92	1.94	1.95	1.97	1.98	2.00	2.01	2.03	2.04	2.05	2.06	2.08	2.09	2.10	2.11	2.13	2.14	2.15	2.16	2.17	2.18	2.20	2.21	2.22	2.23
1270	1.83	1.84	1.86	1.87	1.88	1.89	1.91	1.92	1.94	1.95	1.96	1.97	1.99	2.00	2.01	2.02	2.03	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12	2.13
1280	1.75	1.76	1.77	1.79	1.80	1.81	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.91	1.93	1.94	1.95	1.96	1.97	1.98	2.00	2.01	2.02	2.03	2.04	2.05
1290	1.68	1.69	1.70	1.71	1.72	1.74	1.75	1.76	1.78	1.79	1.80	1.81	1.82	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.94	1.95	1.96	1.97
1300	1.60	1.61	1.63	1.64	1.66	1.67	1.68	1.69	1.71	1.72	1.73	1.74	1.75	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89
1310	1.54	1.55	1.56	1.57	1.59	1.60	1.61	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82
1320	1.48	1.49	1.50	1.52	1.53	1.54	1.55	1.56	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75
1330	1.42	1.43	1.45	1.46	1.47	1.48	1.49	1.50	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69
1340	1.37	1.38	1.39	1.40	1.41	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.62	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63
1350	1.31	1.33	1.34	1.35	1.36	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	
1360	1.27	1.28	1.29	1.30	1.31	1.32	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.48	1.49	1.50	1.51	1.52
1370	1.22	1.23	1.24	1.25	1.26	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.43	1.44	1.45	1.46	1.47
1380	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.41	1.42
1390	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.34	1.35	1.36	1.37	1.38
1400	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.27	1.28	1.29	1.30	1.31	1.32	1.32	1.33
1410	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.25	1.26	1.27	1.28	1.28	1.29
1420	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.17	1.18	1.19	1.20	1.21	1.22	1.22	1.23	1.24	1.24	1.25
1430	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.16	1.17	1.18	1.18	1.19	1.20	1.21	1.22
1440	.964	.974	.984	.994	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.10	1.11	1.12	1.13	1.14	1.14	1.15	1.15	1.16	1.17	1.18
1450	.935	.945	.955	.964	.974	.983	.992	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.07	1.08	1.09	1.09	1.10	1.11	1.12	1.13	1.13	1.14	1.15
1460	.906	.916	.925	.934	.944	.953	.962	.971	.980	.990	1.00	1.01	1.01	1.02	1.03	1.04	1.05	1.06	1.06	1.07	1.08	1.09	1.10	1.10	1.11	1.12
1470	.875	.885	.895	.905	.915	.924	.934	.943	.951	.960	.969	.977	.985	.993	1.00	1.01	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.07	1.08	1.08
1480	.851	.860	.869	.878	.887	.896	.905	.915	.924	.933	.941	.950	.958	.966	.974	.982	.990	.998	1.01	1.01	1.02	1.03	1.03	1.04	1.05	1.05
1490	.824	.834	.844	.853	.862	.871	.880	.889	.898	.906	.914	.922	.930	.939	.947	.956	.963	.970	.977	.984	.991	.998	1.01	1.01	1.02	1.02
1500	.799	.809	.819	.828	.837	.846	.855	.864	.872	.881	.890	.898	.905	.913	.921	.929	.937	.944	.952	.959	.966	.973	.980	.987	.994	1.00

Note—This table is calculated taking the specific gravity of the solution as 1.

TABLE VI. NUMBER OF CUBIC FEET FOR EACH FOOT OF DEPTH OF CYLINDRICAL TANKS

Diameter, Feet.

Diameter, Inches	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	78.54	95.03	113.1	132.7	153.9	176.7	201.1	227.0	254.5	283.5	314.2	346.4	380.1	415.5	452.4	490.9	530.9	572.6	615.8	660.5	706.9	754.8
½	79.19	95.75	113.9	133.5	154.8	177.7	202.1	228.1	255.6	284.7	315.5	347.7	381.5	417.0	453.9	492.5	532.6	574.3	617.6	662.4	708.8	756.8
1	79.85	96.48	114.7	134.4	155.8	178.7	203.2	229.2	256.8	286.0	316.8	349.1	383.0	418.5	455.5	494.2	534.3	576.1	619.4	664.3	710.8	758.8
1½	80.51	97.20	115.5	135.3	156.7	179.7	204.2	230.3	258.0	287.2	318.1	350.5	384.4	420.0	457.1	495.8	536.0	577.8	621.2	666.2	712.7	760.8
2	81.18	97.93	116.3	136.2	157.6	180.7	205.3	231.5	259.2	288.5	319.4	351.9	385.9	421.5	458.7	497.4	537.8	579.6	623.1	668.1	714.7	762.9
2½	81.85	98.66	117.1	137.0	158.5	181.7	206.3	232.6	260.4	289.7	320.7	353.3	387.3	423.0	460.3	499.0	539.5	581.4	624.9	670.0	716.7	764.9
3	82.52	99.40	117.9	137.9	159.5	182.7	207.4	233.7	261.6	291.0	322.1	354.7	388.8	424.6	461.9	500.7	541.2	583.2	626.8	672.0	718.7	767.0
3½	83.19	100.1	118.7	138.7	160.4	183.7	208.4	234.8	262.8	292.3	323.4	356.0	390.2	426.1	463.4	502.4	542.9	585.0	628.6	673.9	720.7	769.0
4	83.86	100.9	119.5	139.6	161.4	184.7	209.5	236.0	264.0	293.6	324.7	357.4	391.7	427.6	465.0	504.1	544.6	586.8	630.5	675.8	722.7	771.1
4½	84.54	101.6	120.3	140.5	162.3	185.7	210.6	237.1	265.2	294.8	326.0	358.8	393.2	429.1	466.6	505.7	546.3	588.6	632.3	677.7	724.6	773.1
5	85.22	102.4	121.1	141.4	163.2	186.7	211.7	238.2	266.4	296.1	327.4	360.2	394.7	430.7	468.2	507.4	548.1	590.4	634.2	679.6	726.6	775.2
5½	85.90	103.1	121.9	142.2	164.1	187.7	212.7	239.3	267.6	297.3	328.7	361.6	396.1	432.2	469.8	509.0	549.8	592.2	636.0	681.5	728.6	777.2
6	86.59	103.9	122.7	143.1	165.1	188.7	213.8	240.5	268.8	298.6	330.1	363.1	397.6	433.7	471.4	510.7	551.5	594.0	637.9	683.5	730.6	779.3
6½	87.28	104.6	123.5	144.0	166.0	189.7	214.9	241.6	270.0	299.9	331.4	364.5	399.1	435.2	473.0	512.3	553.2	595.8	639.8	685.4	732.6	781.3
7	87.97	105.4	124.4	144.9	167.0	190.7	216.0	242.8	271.2	301.2	332.8	365.9	400.6	436.8	474.6	514.0	555.0	597.6	641.7	687.4	734.6	783.4
7½	88.66	106.1	125.2	145.8	167.9	191.7	217.1	243.9	272.4	302.5	334.1	367.3	402.0	438.3	476.2	515.7	556.7	599.4	643.5	689.3	736.6	785.5
8	89.36	106.9	126.0	146.7	168.9	192.8	218.2	245.1	273.7	303.8	335.5	368.7	403.5	439.9	477.9	517.4	558.5	601.2	645.4	691.2	738.6	787.6
8½	90.06	107.6	126.8	147.6	169.9	193.8	219.3	246.2	274.9	305.1	336.8	370.1	405.0	441.4	479.5	519.1	560.2	603.0	647.3	693.1	740.6	789.6
9	90.76	108.4	127.7	148.5	170.9	194.8	220.4	247.4	276.1	306.4	338.2	371.5	406.5	443.0	481.1	520.8	562.0	604.8	649.2	695.1	742.6	791.7
9½	91.47	109.2	128.5	149.4	171.8	195.8	221.5	248.6	277.3	307.6	339.5	372.9	408.0	444.5	482.7	522.4	563.7	606.6	651.0	697.0	744.6	793.8
10	92.18	110.0	129.4	150.3	172.8	196.9	222.6	249.8	278.6	308.9	340.9	374.4	409.5	446.1	484.4	524.4	565.6	608.4	652.9	699.0	746.7	795.9
10½	92.89	110.7	130.2	151.2	173.8	197.9	223.7	250.9	279.8	310.2	342.2	375.8	411.0	447.7	486.0	525.8	567.2	610.2	654.8	700.9	748.7	798.0
11	93.60	111.5	131.0	152.1	174.8	199.0	224.8	252.1	281.0	311.5	343.6	377.3	412.5	449.3	487.6	527.5	569.0	612.1	656.7	702.9	750.7	800.1
11½	94.31	112.3	131.8	153.0	175.7	200.0	225.9	253.3	282.2	312.8	345.0	378.7	414.0	450.8	489.2	529.2	570.8	613.9	658.6	704.9	752.7	802.1

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TABLE VI. NUMBER OF CUBIC FEET FOR EACH FOOT OF DEPTH OF CYLINDRICAL TANKS—Cont.

Diameter, Feet

Diameter, Inches	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
0	804.2	855.3	907.9	962.1	1018	1075	1134	1195	1257	1320	1385	1452	1521	1590	1662	1735	1810	1886	1963	2043	2124	2206	2290
½	806.3	857.4	910.1	964.4	1020	1077	1136	1197	1259	1323	1388	1455	1523	1593	1665	1738	1813	1889	1966	2046	2127	2209	2293
1	808.4	859.6	912.4	966.7	1023	1080	1139	1200	1262	1326	1391	1458	1526	1596	1668	1741	1816	1892	1970	2050	2131	2213	2297
1½	810.5	861.8	914.6	969.0	1025	1082	1141	1202	1264	1328	1393	1460	1529	1599	1671	1744	1819	1895	1973	2053	2134	2216	2300
2	812.6	864.0	916.8	971.5	1027	1085	1144	1205	1267	1331	1396	1463	1532	1602	1674	1747	1822	1899	1977	2056	2137	2220	2304
2½	814.7	866.1	919.0	973.6	1029	1087	1146	1207	1269	1333	1399	1466	1535	1605	1677	1750	1825	1902	1980	2059	2140	2223	2307
3	816.9	868.3	921.3	975.9	1032	1090	1149	1210	1272	1336	1402	1469	1538	1608	1680	1753	1828	1905	1983	2063	2144	2227	2311
3½	819.0	870.5	923.5	978.2	1034	1092	1151	1212	1275	1339	1405	1472	1541	1611	1683	1756	1831	1908	1986	2066	2147	2230	2315
4	821.1	872.7	925.8	980.5	1037	1095	1154	1215	1278	1342	1408	1475	1544	1614	1686	1760	1835	1911	1990	2070	2151	2234	2319
4½	823.2	874.8	928.0	982.8	1039	1097	1156	1217	1280	1344	1410	1477	1546	1617	1689	1763	1838	1914	1993	2073	2154	2237	2322
5	825.3	877.0	930.3	985.2	1042	1100	1159	1220	1283	1347	1413	1480	1549	1620	1692	1766	1841	1918	1996	2076	2158	2241	2326
5½	827.4	879.2	932.5	987.5	1044	1102	1161	1222	1285	1350	1416	1483	1552	1623	1695	1769	1844	1921	1999	2079	2161	2244	2329
6	829.6	881.4	934.8	989.8	1046	1104	1164	1225	1288	1353	1419	1486	1555	1626	1698	1772	1847	1924	2003	2083	2165	2248	2333
6½	831.7	883.6	937.0	992.1	1048	1106	1166	1228	1291	1355	1421	1489	1558	1629	1701	1775	1850	1927	2006	2086	2168	2251	2336
7	833.8	885.8	939.3	994.5	1051	1109	1169	1231	1294	1358	1424	1492	1561	1632	1704	1778	1854	1931	2010	2090	2172	2255	2340
7½	835.9	888.0	941.6	996.8	1053	1111	1171	1233	1296	1361	1427	1495	1564	1635	1707	1781	1857	1934	2013	2093	2175	2258	2343
8	838.1	890.2	943.9	999.1	1056	1114	1174	1236	1299	1364	1430	1498	1567	1638	1710	1785	1860	1937	2016	2097	2179	2262	2347
8½	840.2	892.4	946.1	1001	1058	1116	1176	1238	1301	1366	1432	1500	1570	1641	1713	1788	1863	1940	2019	2100	2182	2265	2351
9	842.4	894.6	948.4	1004	1061	1119	1179	1241	1304	1369	1435	1503	1573	1644	1717	1791	1867	1944	2023	2103	2185	2269	2354
9½	844.5	896.8	950.1	1006	1063	1121	1181	1243	1307	1371	1438	1506	1576	1647	1720	1794	1870	1947	2026	2106	2188	2273	2357
10	846.7	899.0	953.0	1008	1066	1124	1184	1246	1310	1374	1441	1509	1579	1650	1723	1797	1873	1950	2029	2110	2192	2276	2361
10½	848.8	901.2	955.2	1010	1068	1126	1186	1248	1312	1377	1444	1512	1582	1653	1726	1800	1876	1953	2032	2113	2195	2279	2365
11	851.0	903.5	957.5	1013	1070	1129	1189	1251	1315	1380	1447	1515	1585	1656	1729	1803	1879	1957	2036	2117	2199	2283	2369
11½	853.1	905.7	959.8	1015	1072	1131	1192	1254	1317	1382	1450	1518	1587	1659	1732	1806	1882	1960	2039	2120	2202	2286	2372

Diameter, Inches	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
0	2376	2463	2552	2642	2734	2827	2922	3019	3117	3217	3318	3421	3526	3632	3739	3848	3959	4072	4185	4301	4418	4536
½	2379	2466	2555	2646	2738	2831	2926	3023	3121	3221	3322	3425	3530	3636	3743	3853	3963	4076	4190	4306	4423	4541
1	2383	2470	2559	2650	2742	2835	2930	3027	3125	3225	3327	3430	3534	3641	3748	3858	3968	4081	4195	4311	4428	4546
1½	2386	2474	2563	2653	2745	2839	2934	3031	3129	3229	3331	3434	3538	3645	3752	3862	3973	4085	4200	4315	4433	4551
2	2390	2478	2567	2657	2749	2843	2938	3035	3134	3234	3335	3438	3543	3650	3757	3867	3978	4090	4205	4320	4438	4556
2½	2393	2481	2570	2661	2753	2847	2942	3039	3138	3238	3339	3442	3547	3654	3761	3871	3982	4095	4209	4325	4442	4561
3	2397	2485	2574	2665	2757	2851	2946	3043	3142	3242	3344	3447	3552	3658	3766	3876	3987	4100	4214	4330	4447	4566
3½	2401	2488	2578	2669	2761	2855	2950	3047	3146	3246	3348	3451	3556	3662	3770	3880	3991	4104	4219	4335	4452	4571
4	2405	2492	2582	2673	2765	2859	2954	3052	3150	3251	3352	3456	3561	3667	3775	3885	3996	4109	4224	4340	4457	4576
4½	2408	2496	2585	2676	2769	2863	2958	3056	3154	3255	3356	3460	3565	3671	3780	3889	4001	4114	4228	4344	4462	4581
5	2412	2500	2589	2680	2773	2867	2963	3060	3159	3259	3361	3465	3570	3676	3785	3894	4006	4119	4233	4349	4467	4586
5½	2415	2503	2593	2684	2777	2871	2967	3064	3163	3263	3365	3469	3574	3680	3789	3899	4010	4123	4238	4354	4472	4591
6	2419	2507	2597	2688	2781	2875	2971	3068	3167	3267	3370	3473	3578	3685	3794	3904	4015	4128	4243	4359	4477	4596
6½	2422	2511	2600	2691	2784	2879	2975	3072	3171	3271	3374	3477	3582	3689	3798	3908	4020	4133	4248	4364	4482	4601
7	2426	2515	2604	2695	2788	2883	2979	3076	3175	3276	3378	3482	3587	3694	3803	3913	4025	4138	4253	4369	4487	4606
7½	2430	2518	2608	2699	2792	2887	2983	3080	3179	3280	3382	3486	3591	3698	3807	3917	4029	4142	4257	4374	4492	4611
8	2434	2522	2612	2703	2796	2891	2987	3084	3184	3284	3387	3491	3596	3703	3812	3922	4034	4147	4262	4379	4497	4616
8½	2437	2525	2615	2707	2800	2895	2991	3088	3188	3288	3391	3495	3600	3707	3816	3926	4038	4152	4267	4383	4502	4621
9	2441	2529	2619	2711	2804	2899	2995	3093	3192	3293	3395	3499	3605	3712	3821	3931	4043	4157	4272	4388	4507	4626
9½	2444	2533	2623	2715	2808	2903	2999	3097	3196	3297	3399	3503	3609	3716	3825	3936	4048	4161	4276	4393	4512	4631
10	2448	2537	2627	2719	2812	2907	3003	3101	3200	3301	3404	3508	3614	3721	3830	3941	4053	4166	4281	4398	4517	4636
10½	2452	2540	2630	2722	2816	2910	3007	3105	3204	3305	3408	3512	3618	3725	3834	3945	4057	4171	4286	4403	4522	4641
11	2456	2544	2634	2726	2820	2914	3011	3109	3209	3310	3413	3517	3623	3730	3839	3950	4062	4176	4291	4408	4527	4647
11½	2459	2548	2638	2730	2823	2918	3015	3113	3213	3314	3417	3521	3627	3734	3843	3954	4067	4180	4296	4413	4531	4652

Diameter, Inches	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
0	4657	4778	4902	5027	5133	5281	5411	5542	5675	5809	5945	6082	6221	6362	6504	6648	6793	6940	7088	7238	7390	7543	7698
½	4662	4783	4907	5032	5158	5286	5416	5547	5680	5814	5950	6088	6227	6368	6510	6654	6799	6946	7094	7244	7396	7549	7704
1	4667	4789	4912	5037	5164	5292	5421	5553	5686	5820	5956	6094	6233	6374	6516	6660	6805	6952	7101	7251	7403	7556	7711
1½	4672	4794	4917	5042	5169	5297	5426	5558	5691	5825	5961	6099	6238	6379	6522	6666	6811	6958	7107	7257	7409	7562	7717
2	4677	4799	4922	5048	5174	5303	5432	5564	5697	5831	5967	6105	6244	6385	6528	6672	6817	6964	7113	7263	7415	7569	7724
2½	4682	4804	4927	5053	5179	5308	5437	5569	5702	5837	5973	6111	6250	6391	6534	6678	6823	6970	7119	7269	7421	7575	7730
3	4687	4809	4933	5058	5185	5313	5443	5575	5708	5843	5979	6117	6256	6397	6540	6684	6829	6977	7126	7276	7428	7581	7737
3½	4692	4814	4938	5063	5190	5318	5448	5580	5713	5848	4984	6122	6262	6403	6546	6690	6835	6983	7132	7282	7434	7587	7743
4	4697	4819	4943	5069	5195	5324	5454	5586	5719	5954	5990	6128	6268	6409	6552	6696	6842	6989	7138	7289	7441	7594	7750
4½	4702	4824	4848	5074	5200	5329	5459	5591	5724	5859	5996	6134	6274	6415	6558	6702	6848	6995	7144	7295	7447	7600	7756
5	4707	4830	4954	5079	5206	5335	5465	5597	5730	5865	6002	6140	6280	6421	6564	6708	6854	7001	7151	7301	7453	7607	7763
5½	4712	4835	4959	5084	5211	5340	5470	5602	5735	5871	6007	6145	6285	6427	6570	6714	6860	7007	7157	7307	7459	7613	7769
6	4717	4840	4964	5090	5217	5346	5476	5608	5741	5877	6013	6151	6291	6433	6576	6720	6866	7014	7163	7314	7466	7620	7776
6½	4722	4845	4969	5095	5222	5351	5481	5613	5747	5882	6019	6157	6297	6438	6582	6726	6872	7020	7169	7320	7472	7626	7782
7	4727	4850	4974	5100	5227	5356	5487	5619	5753	5888	6025	6163	6303	6444	6588	6732	6878	7026	7176	7326	7479	7633	7789
7½	4732	4855	4979	5105	5232	5361	5492	5624	5758	5893	6030	6169	6309	6450	6594	6738	6884	7032	7182	7332	7485	7639	7795
8	4738	4860	4985	5111	5238	5367	5498	5630	5764	5899	6036	6175	6315	6456	6600	6744	6891	7039	7188	7339	7492	7646	7802
8½	4743	4865	4990	5116	5243	5372	5503	5635	5769	5905	6042	6180	6320	6462	6606	6750	6897	7045	7194	7345	7498	7652	7808
9	4748	4871	4995	5121	5249	5378	5509	5641	5775	5911	6048	6186	6326	6468	6612	6756	6903	7051	7201	7352	7505	7659	7815
9½	4753	4876	5000	5126	5254	5383	5514	5646	5780	5916	6053	6192	6332	6474	6618	6762	6900	7057	7207	7358	7511	7665	7821
10	4758	4881	5006	5132	5260	5389	5520	5652	5786	5922	6059	6198	6338	6480	6624	6769	6915	7063	7213	7364	7517	7672	7828
10½	4763	4886	5011	5137	5265	5394	5525	5657	5792	5927	6065	6203	6344	6486	6630	6775	6921	7069	7219	7370	7523	7678	7834
11	4768	4891	5016	5142	5270	5400	5531	5663	5798	5933	6071	6209	6350	6492	6636	6781	6927	7076	7226	7377	7530	7685	7841
11½	4773	4896	5021	5147	5275	5405	5536	5669	5803	5939	6076	6215	6356	6498	6642	6787	6933	7082	7232	7383	7536	7691	7847
																							7854

ing proper allowance for moisture, checks the tonnage as determined in the cyanide plant by the specific-gravity method within one-eighth of one per cent., the specific-gravity method giving the higher result.

Use of the Tables

The specific gravity of the dry slime, the specific gravity of the solution and the weight of 1000 c.c. of the pulp having been determined by the methods just described, the necessary data for the use of the first five tables are at hand. The specific gravity of the dry slime may be determined accurately once and need not be again determined unless there is a change in the character of the ore treated; but in order to insure that there has been no change of consequence it is best to repeat this determination occasionally.

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In most cases, the specific gravity of the solution will remain more or less constant for some time. Frequent determination may be made until this point is established. It is necessary to determine the weight of 1000 c.c. of the pulp for each individual slime charge.

Table 1 gives the percentage by weight of the dry slime in pulps weighing from 1010 to 1500 grams per liter, and in which the specific gravity of the dry slime ranges from 2.50 to 3. The percentages given are those resulting when the specific gravity of the solution is taken as 1. In the column headed "correction" and adjoining each percentage, is given the amount to be deducted from the corresponding percentage for each increase of 0.001 in the specific gravity of the solution. This corection multiplied by the number of thousandths, expressed as a whole number, by which the specific gravity of the solution exceeds 1 and subtracted from the percentage given in the table, will give the corrected percentage.

This table is generally useful in all plants where wet pulps are handled. It might be mentioned that it would be particularly useful in connection with the control of classifiers. The following example will illustrate the method of using this table:

Given a slime pulp weighing 1200 grams per liter, the specific gravity of the dry slime being 2.60, and the specific gravity of the solution 1.005. At the intersection of the horizontal column headed 1200 (weight of one liter of the wet pulp) and the vertical column headed 2.60 (specific gravity of the dry slime) will be found 27.08, which is the percentage of dry slime in the pulp if the specific gravity of the solution is 1. In the adjoining column directly opposite this percentage is found 0.119, which is the amount to be deducted for each increase of 0.001 in the specific gravity of the solution. Multiplying this value by five produces 0.595; this subtracted from 27.08 gives 26.48, the corrected percentage.

Table 1a gives the logarithms of the percentages in Table 1. In this table the natural values for the correction are given. On account of the use of the correction involving subtraction, it is impossible to use logarithms in applying it. This table will, therefore, be chiefly useful to those who use logarithms in making their computations, but who do not desire to apply the correction for the specific gravity of the solution.

Table 2 gives the weight of one cubic foot of pulp for pulps weighing from 1010 to 1500 grams per liter. Neither the specific gravity of the dry slime nor of the solution need be considered in using this table. This table is chiefly useful in connection with calculating the foundations for tanks which are to contain pulp. Table 2a gives the logarithms of the values contained in Table 2. Curve 2b shows graphically some of the values of Table 2.

TABLE VIb. LOGARITHMS OF THE NUMBER OF CUBIC FEET FOR EACH FOOT OF DEPTH OF CYLINDRICAL TANKS

Diameter, Inches	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	.8951	.9779	.0535	.1229	.1872	.2472	.3034	.3560	.4057	.4526	.4972	.5396	.5799	.6186	.6555	.6910	.7250	.7579	.7894	.8199	.8494	.8778
½	.8987	.9811	.0565	.1255	.1898	.2497	.3056	.3581	.4076	.4544	.4990	.5412	.5815	.6201	.6570	.6924	.7264	.7591	.7907	.8211	.8505	.8790
1	.9023	.9844	.0596	.1284	.1926	.2521	.3079	.3602	.4096	.4564	.5008	.5429	.5832	.6217	.6585	.6939	.7278	.7605	.7920	.8224	.8517	.8801
1½	.9058	.9877	.0626	.1313	.1951	.2545	.3101	.3623	.4116	.4582	.5026	.5447	.5848	.6232	.6600	.6953	.7292	.7618	.7932	.8236	.8529	.8813
2	.9094	.9909	.0656	.1342	.1976	.2570	.3124	.3646	.4136	.4601	.5043	.5464	.5865	.6248	.6615	.6967	.7306	.7631	.7946	.8248	.8541	.8825
2½	.9130	.9941	.0686	.1367	.2000	.2594	.3145	.3666	.4156	.4619	.5061	.5481	.5880	.6263	.6630	.6981	.7320	.7645	.7958	.8261	.8553	.8838
3	.9166	.9974	.0715	.1396	.2028	.2617	.3168	.3687	.4176	.4639	.5080	.5499	.5897	.6280	.6645	.6996	.7334	.7658	.7971	.8274	.8565	.8848
3½	.9201	.0004	.0745	.1421	.2052	.2641	.3189	.3707	.4196	.4658	.5097	.5514	.5913	.6295	.6660	.7010	.7347	.7672	.7984	.8286	.8578	.8859
4	.9236	.0039	.0774	.1449	.2079	.2665	.3212	.3729	.4216	.4678	.5115	.5532	.5930	.6310	.6675	.7025	.7361	.7685	.7997	.8298	.8590	.8871
4½	.9271	.0069	.0803	.1477	.2103	.2688	.3235	.3749	.4236	.4695	.5132	.5549	.5946	.6326	.6689	.7039	.7374	.7698	.8009	.8310	.8601	.8882
5	.9305	.0103	.0831	.1504	.2127	.2711	.3257	.3769	.4255	.4714	.5151	.5565	.5963	.6342	.6704	.7054	.7389	.7711	.8022	.8323	.8613	.8894
5½	.9340	.0133	.0860	.1529	.2151	.2735	.3278	.3789	.4275	.4732	.5168	.5582	.5978	.6357	.6719	.7067	.7402	.7725	.8035	.8335	.8625	.8905
6	.9375	.0166	.0888	.1556	.2177	.2758	.3300	.3811	.4294	.4751	.5186	.5600	.5994	.6372	.6734	.7082	.7415	.7738	.8048	.8347	.8637	.8917
6½	.9409	.0195	.0917	.1584	.2201	.2781	.3322	.3831	.4314	.4770	.5204	.5617	.6011	.6387	.6749	.7096	.7429	.7751	.8060	.8359	.8649	.8928
7	.9443	.0228	.0948	.1611	.2227	.2804	.3345	.3852	.4333	.4789	.5222	.5634	.6027	.6403	.6763	.7110	.7443	.7764	.8073	.8372	.8661	.8940
7½	.9477	.0257	.0976	.1638	.2251	.2826	.3367	.3872	.4352	.4807	.5239	.5650	.6042	.6418	.6778	.7124	.7456	.7777	.8085	.8384	.8672	.8951
8	.9511	.0290	.1004	.1664	.2276	.2851	.3389	.3893	.4373	.4826	.5257	.5667	.6058	.6434	.6793	.7138	.7470	.7790	.8098	.8396	.8684	.8963
8½	.9545	.0318	.1031	.1691	.2302	.2874	.3410	.3913	.4392	.4844	.5274	.5683	.6075	.6448	.6808	.7153	.7483	.7803	.8111	.8408	.8696	.8974
9	.9579	.0350	.1062	.1717	.2327	.2896	.3432	.3934	.4411	.4863	.5292	.5700	.6091	.6464	.6822	.7167	.7497	.7816	.8124	.8420	.8708	.8986
9½	.9613	.0382	.1089	.1744	.2350	.2918	.3454	.3955	.4429	.4880	.5308	.5716	.6107	.6479	.6837	.7180	.7510	.7829	.8136	.8432	.8719	.8997
10	.9646	.0414	.1119	.1770	.2375	.2942	.3475	.3976	.4450	.4898	.5326	.5733	.6123	.6494	.6852	.7194	.7524	.7842	.8148	.8445	.8731	.9009
10½	.9680	.0441	.1146	.1796	.2400	.2964	.3497	.3995	.4468	.4916	.5343	.5750	.6138	.6510	.6866	.7208	.7537	.7855	.8161	.8457	.8743	.9020
11	.9713	.0473	.1173	.1821	.2425	.2989	.3518	.4016	.4487	.4935	.5361	.5767	.6154	.6525	.6881	.7222	.7551	.7868	.8174	.8469	.8755	.9031
11½	.9746	.0504	.1199	.1847	.2448	.3010	.3539	.4036	.4506	.4953	.5378	.5783	.6170	.6540	.6895	.7236	.7565	.7881	.8180	.8481	.8766	.9042

Diameter, Inches	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
0	.9054	.9321	.9580	.9832	.0077	.0314	.0546	.0774	.0993	.1206	.1414	.1620	.1821	.2014	.2206	.2393	.2577	.2755	.2929	.3103	.3272	.3436	.3598
½	.9065	.9332	.9591	.9843	.0086	.0322	.0554	.0781	.1000	.1216	.1424	.1629	.1827	.2022	.2214	.2400	.2584	.2762	.2936	.3109	.3278	.3442	.3604
1	.9076	.9343	.9602	.9853	.0099	.0334	.0565	.0792	.1011	.1225	.1433	.1638	.1836	.2030	.2222	.2408	.2591	.2769	.2945	.3118	.3286	.3450	.3612
1½	.9088	.9354	.9612	.9863	.0107	.0342	.0573	.0799	.1017	.1232	.1440	.1644	.1844	.2038	.2230	.2415	.2598	.2776	.2951	.3124	.3292	.3456	.3617
2	.9099	.9365	.9623	.9874	.0116	.0354	.0584	.0810	.1028	.1242	.1449	.1652	.1853	.2047	.2238	.2423	.2605	.2785	.2960	.3130	.3298	.3464	.3625
2½	.9110	.9376	.9633	.9884	.0124	.0362	.0592	.0817	.1035	.1248	.1458	.1661	.1861	.2055	.2245	.2430	.2613	.2792	.2967	.3137	.3304	.3469	.3630
3	.9122	.9387	.9644	.9894	.0137	.0374	.0603	.0828	.1045	.1258	.1467	.1670	.1870	.2063	.2253	.2438	.2620	.2799	.2973	.3145	.3312	.3477	.3638
3½	.9133	.9398	.9654	.9904	.0145	.0382	.0611	.0835	.1055	.1268	.1477	.1679	.1878	.2071	.2261	.2445	.2627	.2806	.2980	.3151	.3318	.3483	.3646
4	.9144	.9409	.9665	.9914	.0158	.0394	.0622	.0846	.1065	.1278	.1486	.1688	.1886	.2079	.2269	.2455	.2636	.2813	.2989	.3160	.3326	.3491	.3653
4½	.9155	.9419	.9675	.9925	.0166	.0402	.0630	.0853	.1072	.1284	.1492	.1694	.1892	.2087	.2276	.2463	.2643	.2819	.2995	.3166	.3332	.3497	.3659
5	.9166	.9430	.9686	.9935	.0179	.0414	.0641	.0864	.1082	.1294	.1501	.1703	.1901	.2095	.2284	.2470	.2651	.2828	.3002	.3172	.3341	.3504	.3666
5½	.9177	.9441	.9696	.9945	.0187	.0422	.0648	.0871	.1089	.1303	.1511	.1711	.1909	.2103	.2292	.2477	.2658	.2835	.3008	.3179	.3347	.3510	.3672
6	.9189	.9452	.9707	.9955	.0195	.0430	.0660	.0881	.1099	.1313	.1520	.1720	.1917	.2111	.2299	.2485	.2665	.2842	.3017	.3187	.3355	.3518	.3679
6½	.9200	.9463	.9717	.9966	.0204	.0438	.0667	.0892	.1109	.1319	.1526	.1729	.1926	.2119	.2307	.2492	.2672	.2849	.3023	.3193	.3361	.3524	.3685
7	.9211	.9473	.9728	.9976	.0216	.0449	.0678	.0903	.1119	.1329	.1535	.1738	.1934	.2127	.2315	.2499	.2681	.2858	.3032	.3201	.3369	.3531	.3692
7½	.9222	.9484	.9739	.9986	.0224	.0457	.0686	.0910	.1126	.1339	.1544	.1746	.1942	.2135	.2322	.2507	.2688	.2865	.3038	.3208	.3375	.3537	.3699
8	.9233	.9495	.9749	.9996	.0237	.0469	.0697	.0920	.1136	.1348	.1553	.1755	.1951	.2143	.2330	.2516	.2695	.2871	.3045	.3216	.3383	.3545	.3705
8½	.9244	.9506	.9759	.0004	.0245	.0477	.0704	.0927	.1143	.1355	.1559	.1761	.1959	.2151	.2338	.2524	.2702	.2878	.3051	.3222	.3389	.3551	.3713
9	.9255	.9516	.9770	.0017	.0257	.0488	.0715	.0938	.1153	.1364	.1569	.1770	.1967	.2159	.2348	.2531	.2711	.2887	.3060	.3228	.3395	.3558	.3718
9½	.9266	.9527	.9780	.0026	.0265	.0496	.0722	.0945	.1163	.1370	.1578	.1778	.1976	.2167	.2355	.2538	.2718	.2894	.3066	.3235	.3400	.3566	.3724
10	.9277	.9538	.9791	.0035	.0278	.0508	.0734	.0955	.1173	.1380	.1587	.1787	.1984	.2175	.2363	.2545	.2725	.2900	.3073	.3243	.3408	.3572	.3731
10½	.9288	.9548	.9801	.0043	.0286	.0515	.0741	.0962	.1179	.1389	.1596	.1796	.1992	.2183	.2370	.2553	.2732	.2907	.3079	.3249	.3414	.3577	.3738
11	.9299	.9559	.9811	.0056	.0294	.0527	.0752	.0973	.1189	.1399	.1605	.1804	.2000	.2191	.2378	.2560	.2739	.2916	.3088	.3257	.3422	.3585	.3746
11½	.9310	.9570	.9822	.0005	.0302	.0535	.0763	.0983	.1196	.1405	.1614	.1813	.2006	.2198	.2385	.2567	.2746	.2923	.3094	.3263	.3428	.3591	.3751

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TABLE VIb. LOGARITHMS OF THE NUMBER OF CUBIC FEET FOR EACH FOOT OF DEPTH OF CYLINDRICAL TANKS—Continued

Diameter, Inches	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
0	.3758	.3915	.4069	.4219	.4368	.4513	.4657	.4799	.4937	.5075	.5209	.5342	.5473	.5601	.5728	.5852	.5976	.6098	.6217	.6336	.6452	.6567
½	.3764	.3920	.4074	.4226	.4374	.4519	.4663	.4804	.4943	.5080	.5214	.5347	.5478	.5606	.5732	.5858	.5980	.6102	.6222	.6341	.6457	.6572
1	.3771	.3927	.4081	.4232	.4381	.4526	.4669	.4810	.4949	.5085	.5221	.5353	.5483	.5612	.5738	.5864	.5986	.6108	.6227	.6346	.6462	.6576
1½	.3777	.3934	.4087	.4237	.4385	.4532	.4675	.4816	.4954	.5091	.5226	.5358	.5488	.5617	.5743	.5868	.5991	.6112	.6232	.6350	.6467	.6581
2	.3784	.3941	.4094	.4244	.4392	.4538	.4681	.4822	.4961	.5097	.5231	.5363	.5494	.5623	.5748	.5874	.5997	.6117	.6238	.6355	.6472	.6586
2½	.3789	.3946	.4099	.4250	.4398	.4544	.4686	.4827	.4967	.5103	.5236	.5368	.5499	.5628	.5753	.5878	.6001	.6123	.6242	.6360	.6476	.6591
3	.3797	.3953	.4106	.4257	.4404	.4550	.4692	.4833	.4972	.5108	.5243	.5374	.5505	.5632	.5759	.5884	.6006	.6128	.6247	.6365	.6481	.6595
3½	.3804	.3959	.4113	.4263	.4411	.4556	.4698	.4339	.4978	.5113	.5248	.5379	.5510	.5637	.5763	.5888	.6011	.6132	.6252	.6370	.6486	.6600
4	.3811	.3965	.4120	.4270	.4417	.4562	.4704	.4846	.4983	.5120	.5253	.5386	.5516	.5643	.5769	.5894	.6016	.6137	.6257	.6375	.6490	.6605
4½	.3817	.3972	.4125	.4275	.4423	.4568	.4710	.4852	.4989	.5126	.5258	.5391	.5521	.5648	.5775	.5898	.6022	.6143	.6261	.6379	.6495	.6610
5	.3824	.3979	.4131	.4281	.4429	.4574	.4717	.4857	.4995	.5131	.5265	.5397	.5527	.5654	.5781	.5904	.6027	.6148	.6266	.6384	.6500	.6614
5½	.3829	.3985	.4138	.4288	.4436	.4580	.4723	.4863	.5001	.5136	.5270	.5402	.5532	.5658	.5785	.5910	.6031	.6152	.6272	.6389	.6505	.6619
6	.3836	.3992	.4145	.4294	.4442	.4586	.4729	.4869	.5006	.5141	.5276	.5407	.5536	.5664	.5791	.5915	.6037	.6157	.6277	.6394	.6510	.6624
6½	.3842	.3998	.4150	.4299	.4447	.4592	.4735	.4874	.5012	.5147	.5281	.5412	.5541	.5669	.5796	.5920	.6042	.6163	.6282	.6399	.6515	.6629
7	.3849	.4005	.4156	.4306	.4453	.4598	.4741	.4880	.5017	.5153	.5287	.5418	.5547	.5675	.5801	.5925	.6048	.6168	.6287	.6404	.6520	.6633
7½	.3856	.4011	.4163	.4312	.4459	.4604	.4747	.4886	.5023	.5159	.5292	.5423	.5552	.5680	.5806	.5930	.6052	.6172	.6291	.6409	.6524	.6638
8	.3863	.4017	.4170	.4318	.4465	.4610	.4752	.4891	.5030	.5164	.5298	.5429	.5558	.5686	.5812	.5935	.6057	.6177	.6296	.6414	.6529	.6643
8½	.3869	.4023	.4175	.4325	.4472	.4616	.4758	.4897	.5035	.5169	.5303	.5434	.5563	.5690	.5816	.5940	.6062	.6183	.6301	.6418	.6534	.6647
9	.3876	.4029	.4181	.4331	.4478	.4622	.4764	.4904	.5041	.5176	.5308	.5439	.5569	.5696	.5822	.5945	.6067	.6188	.6306	.6423	.6539	.6653
9½	.3881	.4036	.4188	.4338	.4484	.4628	.4770	.4909	.5046	.5181	.5314	.5444	.5574	.5701	.5826	.5951	.6072	.6192	.6310	.6428	.6544	.6657
10	.3888	.4043	.4195	.4344	.4490	.4634	.4776	.4915	.5051	.5186	.5320	.5451	.5580	.5707	.5832	.5956	.6078	.6197	.6315	.6433	.6549	.6661
10½	.3895	.4048	.4200	.4349	.4496	.4639	.4781	.4921	.5057	.5192	.5325	.5456	.5585	.5711	.5837	.5960	.6082	.6202	.6321	.6437	.6553	.6666
11	.3902	.4055	.4206	.4355	.4502	.4645	.4787	.4926	.5064	.5196	.5331	.5462	.5591	.5717	.5842	.5966	.6087	.6208	.6326	.6442	.6558	.6672
11½	.3908	.4062	.4213	.4362	.4507	.4651	.4793	.4932	.5069	.5204	.5336	.5467	.5595	.5722	.5847	.5970	.6093	.6212	.6331	.6447	.6562	.6676

Diameter, Inches	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
0	.6681	.6792	.6904	.7013	.7121	.7227	.7333	.7437	.7540	.7641	.7742	.7840	.7939	.8036	.8132	.8227	.8321	.8414	.8505	.8596	.8686	.8775	.8864
½	.6686	.6797	.6908	.7017	.7125	.7231	.7337	.7441	.7544	.7645	.7745	.7845	.7943	.8040	.8136	.8231	.8324	.8417	.8509	.8600	.8690	.8779	.8867
1	.6690	.6802	.6913	.7022	.7130	.7236	.7341	.7445	.7548	.7649	.7750	.7849	.7947	.8044	.8140	.8235	.8328	.8421	.8513	.8604	.8694	.8783	.8871
1½	.6695	.6807	.6917	.7026	.7134	.7240	.7345	.7449	.7552	.7653	.7753	.7853	.7950	.8048	.8144	.8239	.8332	.8425	.8517	.8608	.8698	.8786	.8874
2	.6700	.6812	.6921	.7031	.7138	.7245	.7350	.7454	.7556	.7657	.7758	.7857	.7955	.8052	.8148	.8243	.8336	.8429	.8520	.8611	.8701	.8790	.8878
2½	.6704	.6816	.6926	.7035	.7142	.7249	.7354	.7458	.7560	.7662	.7762	.7861	.7959	.8056	.8152	.8247	.8340	.8432	.8524	.8615	.8705	.8794	.8882
3	.6709	.6821	.6931	.7040	.7147	.7253	.7358	.7462	.7565	.7666	.7766	.7865	.7963	.8060	.8156	.8250	.8344	.8437	.8528	.8619	.8709	.8797	.8886
3½	.6714	.6825	.6936	.7044	.7152	.7257	.7362	.7466	.7569	.7670	.7770	.7869	.7967	.8064	.8160	.8254	.8347	.8440	.8532	.8623	.8712	.8801	.8889
4	.6718	.6830	.6940	.7049	.7156	.7262	.7367	.7471	.7573	.7675	.7774	.7873	.7971	.8068	.8164	.8258	.8352	.8444	.8536	.8627	.8716	.8805	.8893
4½	.6723	.6834	.6944	.7054	.7160	.7266	.7371	.7475	.7577	.7678	.7779	.7877	.7975	.8072	.8168	.8262	.8356	.8448	.9539	.8630	.8720	.8808	.8896
5	.6727	.6839	.6950	.7058	.7165	.7271	.7376	.7480	.7582	.7683	.7783	.7882	.7980	.8076	.8172	.8266	.8359	.8452	.8544	.8634	.8723	.8812	.8900
5½	.6732	.6844	.6954	.7062	.7169	.7275	.7380	.7483	.7585	.7687	.7787	.7885	.7983	.8080	.8176	.8270	.8363	.8455	.8547	.8637	.8727	.8816	.8904
6	.6737	.6848	.6958	.7067	.7174	.7280	.7385	.7488	.7590	.7692	.7791	.7889	.7987	.8084	.8180	.8274	.8367	.8460	.8551	.8642	.8731	.8820	.8908
6½	.6741	.6853	.6963	.7071	.7178	.7284	.7389	.7492	.7594	.7695	.7795	.7894	.7991	.8088	.8184	.8278	.8371	.8463	.8555	.8645	.8734	.8823	.8911
7	.6746	.6857	.6967	.7076	.7183	.7288	.7393	.7497	.7599	.7700	.7800	.7898	.7995	.8092	.8188	.8281	.8375	.8467	.8559	.8649	.8738	.8827	.8915
7½	.6750	.6862	.6971	.7080	.7187	.7292	.7397	.7501	.7603	.7703	.7803	.7902	.8000	.8096	.8192	.8285	.8378	.8471	.8562	.8652	.8742	.8830	.8918
8	.6756	.6866	.6977	.7085	.7192	.7297	.7402	.7505	.7607	.7708	.7807	.7906	.8004	.8100	.8195	.8289	.8383	.8475	.8566	.8656	.8746	.8834	.8922
8½	.6761	.6871	.6981	.7089	.7196	.7301	.7406	.7509	.7611	.7712	.7812	.7910	.8007	.8104	.8199	.8293	.8387	.8479	.8570	.8660	.8749	.8838	.8925
9	.6765	.6876	.6985	.7094	.7201	.7306	.7411	.7514	.7616	.7717	.7816	.7914	.8011	.8108	.8203	.8297	.8390	.8482	.8574	.8664	.8754	.8842	.8930
9½	.6770	.6881	.6990	.7098	.7205	.7310	.7415	.7517	.7619	.7720	.7820	.7918	.8015	.8112	.8207	.8301	.8394	.8486	.8578	.8668	.8757	.8845	.8933
10	.6774	.6885	.6995	.7103	.7210	.7315	.7419	.7522	.7624	.7725	.7824	.7923	.8020	.8116	.8211	.8305	.8398	.8490	.8581	.8671	.8760	.8849	.8937
10½	.6779	.6890	.6999	.7107	.7214	.7319	.7423	.7526	.7628	.7728	.7828	.7926	.8024	.8120	.8215	.8309	.8402	.8494	.8585	.8675	.8764	.8852	.8940
11	.6783	.6894	.7004	.7111	.7218	.7324	.7428	.7530	.7633	.7733	.7833	.7930	.8028	.8124	.8219	.8313	.8405	.8498	.8589	.8679	.8768	.8856	.8944
11½	.6788	.6898	.7008	.7116	.7222	.7328	.7432	.7535	.7637	.7737	.7836	.7934	.8032	.8128	.8223	.8317	.8409	.8502	.8593	.8682	.8771	.8860	.8947
																							.8951

Note—The characteristics of the logarithms in the above table are best determined by looking up the natural number to which they refer, and calculating as is done with ordinary logarithms. These characteristics may be 3, 2 or 1. The change in the characteristic can always be told by inspection through the change in the mantissa so that with experience, the characteristic can be immediately deduced from the part of the table in which the logarithm occurs.

Table 3 gives the pounds of dry slime in one cubic foot of pulp for pulps weighing from 1010 to 1500 grams per liter, and in which the specific gravity of the dry slime ranges from 2.50 to 3. The correction for the specific gravity of the solution is applied in the same manner as in Table 1.

Table 3a gives the logarithms of the values given in Table 3. Natural values are given for the corrections for the reason explained in connection with Table 1a.

Table 4 gives the number of cubic feet of pulp to make one ton of dry slime for pulps weighing from 1010 to 1500 grams per liter, and for specific gravities of dry slime from 2.5 to 3. By reference to the formula from which the values in this table are derived, it will be seen that the correction for the specific gravity of the solution should be added to the values given in the table instead of being subtracted as in Tables 1 and 3.

Table 4a gives the logarithms of the values given in Table 4. Natural values are given for the correction for the same reason as in Table 1.

Table 5 gives the dilution (ratio of solution to dry slime) for pulps weighing from 1010 to 1500 grams per liter, and for specific gravities of dry slime from 2.5 to 3. This table is useful in plants where a record is kept of the dilution of each charge.

Table 6 gives the number of cubic feet per foot of depth of circular tanks from 10 to 100 ft. in diameter by steps of one-half inch. Each vertical column in the table is headed by a diameter, given in even feet, which increases by steps by one foot toward the right of the table. Directly beneath each diameter is given the number of cubic feet of capacity per foot of depth for a circular tank of this particular diameter. Reading downward in the table, capacities in cubic feet per foot of depth are given for each increase of ½ in. in diameter. Cubic feet of capacity for one foot of depth, multiplied by the depth of the pulp in the tank, will give the number of cubic feet of content.

Measurements and Example of Use of Tables

Sharwood[28] calls attention to the variations which may exist in the diameter of wooden tanks. Differences of 6 in. or over may be found in tanks over 25 ft. in diameter, due to imperfect construction, unequal settling or unequal shrinkage of the staves. In order that an accurate diameter be obtained, it is necessary to make a number of measurements at different depths and preferably at equal angles and take the average of results thus obtained as being the true diameter. The diam-

[28] "Measurement of Pulp and Tailing," "Min. Mag.," Vol. 1, p. 228.

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eters of steel tanks are also subject to variations due to poor construction and unequal settling, therefore the same directions should be observed as in the case of wooden tanks. Care must also be exercised in ascertaining the average depth of the pulp. A deduction must be made for the number of cubic feet occupied by various devices submerged in the tank, such as agitating gear, decanting pipes, etc.

The following example will illustrate the use of Table 4 in connection with Table 6 in calculating the number of tons of dry slime in a charge of pulp 10 ft. in depth, contained in a tank 30 ft. 6 in. diameter. Given: The specific gravity of the dry slime 2.66; the weight of one liter of pulp 1150 grams; the specific gravity of solution 1.005. Required: The number of tons of dry slime in the charge. In Table 4, at the intersection of the vertical column headed 2.66 and the horizontal column headed 1150, is found 133.3, the number of cubic feet of pulp to make one ton of dry slime when the specific gravity of the solution is 1. In the adjoining column opposite 133.3 is found 0.87, the number of cubic feet to be added to 133.3 for each increase of 0.001 in the specific gravity of the solution; $0.87 \times 5 = 4.35$ (total correction $133.3 + 4.35 = 137.65$ cu. ft. of the pulp specified necessary to make one ton of dry slime. In Table 6 at the intersection of the vertical column headed 30 ft. and the horizontal column headed 6 in., is found 730.6, the number of cubic feet per foot of depth for a tank 30 ft. 6 in. in diameter; $730.6 \times 10 = 7306$, apparent total cubic feet of pulp in the tank. Suppose 5.5 cu. ft. are occupied in the tank by various devices below the pulp level; $7306 - 5.5 = 7300.5$, actual cubic feet of pulp in the tank; $7300.5 \div 137.03 = 53.03$, the number of tons of dry slime in the charge. In order to show the effect of not taking the specific gravity of the solution into account, we have calculated the number of tons of dry slime in the above charge, taking the specific gravity of the solution as 1, and find it to be 54.76, a difference of 1.73 tons.

Curves 1b, 3b, 4b and 5b illustrate how the operator may use the data contained in any of the tables for plotting large-scale curves covering the particular work which he may have in hand.

Curve 1b shows graphically a few of the values given in Table 1. When the specific gravities of the dry slime and solution are constant, or nearly so, a single curve may be plotted, but when there is considerable variation in these factors, the uncorrected percentages for all specific gravities of dry slime and any particular weight of one liter of pulp may be indicated by heavy lines. Directly beneath each heavy line should be light lines giving the corrected percentages for pulps covering the range of the specific gravities of the solutions used. In using this curve, follow the vertical line representing the specific gravity of the dry slime to the point where it intersects the double line representing the weight of one liter of the pulp, drop below to the single line or intermediate point representing the specific gravity of the solution, then follow horizontally, either to the right or left, and read corrected percentage.

Curve 3b shows graphically a few of the values given in Table 3. The plotting and method of using this curve is the same as Curve 1b.

Curve 4b shows graphically some of the values given in Table 4. This curve is plotted similarly to Curves 1b and 3b, except that the single lines, representing the corrected number of cubic feet of pulp, are in this case located above the heavy lines, since the correction is added instead of subtracted as in Curves 1b and 3b.

We are indebted to Prof. L. M. Hoskins of the Department of Applied Mathematics and to Prof. Fernando Sanford of the Department of Physics of Stanford University for several valuable suggestions in connection with this work. We also wish to acknowledge the faithful and painstaking work of E. P. Bly and G. W. Hawley in connection with the making of certain of the routine calculations.

SOLUBILITY OF AIR IN WATER

1000 c.c. of water saturated with air at 760 m.m. pressure contain the following volumes of dissolved gas (calculated to 0° C. and 760 m.m.)

	Temperature of Water						
	0°	5°	10°	15°	20°	25°	30°
Oxygen, c.c.	10.19	8.9	7.9	7.0	6.4	5.8	5.3
Nitrogen, etc.	19.0	16.8	15.0	13.5	12.3	11.3	10.4
Sum of above, c.c.	29.2	25.7	22.8	20.5	18.7	17.1	15.7
Per cent. oxygen in dissolved air (by volume)	34.9	34.7	34.5	34.2	34.0	33.8	33.6

Kaye & Laby's "Chemical & Physical Constants."

WATER

1 ton	= 239.665 gallons = 32.038 cu. ft.
1 acre foot	= 325.850 gallons = 43.560 cu. ft.
1 gallon	= 231 cu. in. = 8.345 lbs. = 0.1337 cu. ft.
1 gallon per min.	= 1,440 gallons or 192.5 cu. ft. or 6 tons per 24 hours.
1 cu. ft.	= 7.48 gallons = 62.425 lbs. = 28.3153 Kilos.
1 miner's inch	= 1½ cu. ft. approximately.
1 Litre	= 2.2046 pounds = 61.027 cu. in. = 1.0567 quarts.
1 lb. pressure	= column of water 2.304 ft. high.
1 ft. hear	= .434 lbs. pressure.

AIR PRESSURE TO OPERATE LIFTS

Lift, Feet	Submergence, Feet	Theoretical gage pressure in lbs. per sq. in. to elevate fluid of specific gravity. 1.0	1.1	1.2	1.3	1.4	1.5
5	7.5	3.2	3.6	3.9	4.2	4.5	4.9
10	15.0	6.5	7.1	7.8	8.4	9.1	9.7
15	22.5	9.7	10.7	11.6	12.6	13.6	14.5
20	30.0	13.0	14.3	15.6	16.9	18.2	19.5
25	37.5	16.2	17.8	19.4	21.0	22.7	24.3
30	45.0	19.5	21.4	23.4	25.3	27.3	29.2
35	52.5	22.7	25.0	27.2	29.5	31.8	34.0
40	60.0	26.0	28.6	31.2	33.8	36.4	39.0
45	67.5	29.2	32.1	35.0	38.0	40.9	43.8
50	75.0	32.5	35.7	39.0	42.2	45.5	48.7
5	10.0	4.3	4.7	5.2	5.6	6.0	6.5
10	20.0	8.7	9.6	10.4	11.3	12.2	13.0
15	30.0	13.0	14.3	15.6	16.9	18.2	19.5
20	40.0	17.3	19.0	20.8	22.5	24.2	25.9
25	50.0	21.6	23.8	25.9	28.1	30.2	32.4
30	60.0	26.0	28.6	31.2	33.8	36.4	39.0
35	70.0	30.3	33.3	36.4	39.4	42.4	45.4
40	80.0	34.6	38.0	41.5	45.0	48.4	51.9
45	90.0	39.0	42.9	46.8	50.7	54.6	58.5
50	100.0	43.3	47.6	52.0	56.3	60.6	64.9

An increase in pressure of from 10 to 20% over the figures given will be necessary in practice.
A. W. Allen in Eng. & Min. Journal.

A cubic foot of water contains 7½ gallons and weighs 62½ pounds.
A miner's inch of water is equal to nine gallons per minute.
A cubic foot per second is equal to 50 miner's inches, or 450 gallons per minute.
A gallon of fresh water weighs 8.34 lbs., and contains 231 cubic inches.
A cubic foot of fresh water weighs 62.5 lbs. and contains 1728 cubic inches or 7.5 gallons.
Doubling the diameter of pipe increases its capacity four times.
Theoretically water can be raised by suction 33 feet, but practically only 25 to 28 feet.
27,154 gallons of water will cover one acre one inch deep.
225 gallons per minute, or 25 miner's inches, will be sufficient to cover one acre one inch deep in two hours and one minute.

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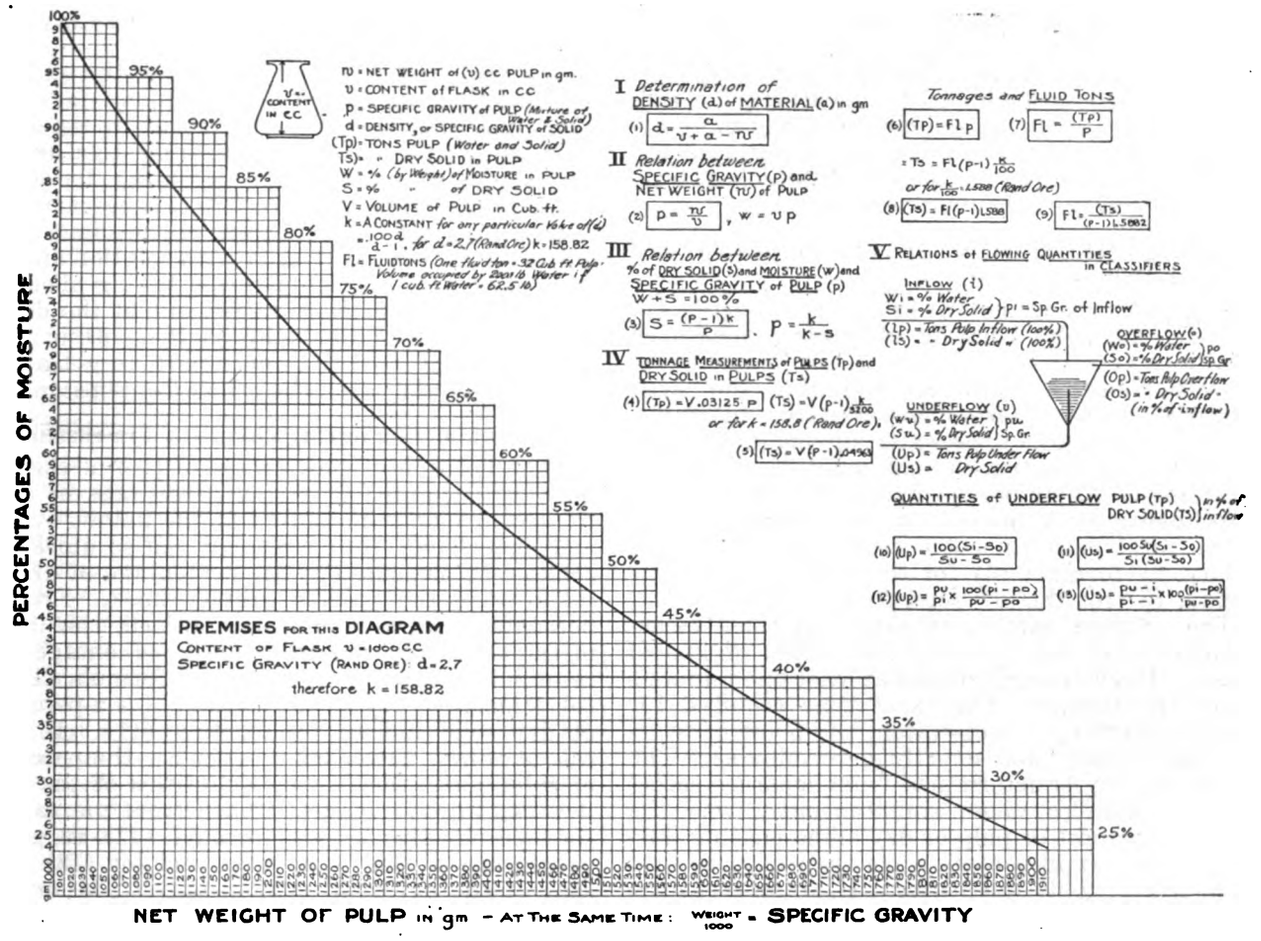
PRACTICAL APPLICATION OF THE SPECIFIC GRAVITY FLASK

By H. STADLER

*The principal objects of these notes is to show the great practical possibilities of the specific gravity flask, which in future should prove to be one of the most useful and indispensable instruments for efficient and reliable control of the condition of mill-pulp. W. J. Sharwood's admirable article on the measurement of pulp and tailing[1] is presumably familiar to all millmen who have to deal practically with the handling of pulp. The present notes do not pretend to add much that is really novel, but I trust that some practical conclusions drawn from the above and other papers on this subject[2] will be welcome to those whose daily duties leave very little spare time for a thorough study of technical literature.

1. Determination of Density (Specific Gravity) of Solids

If the specific gravity of the solid ore under treatment be not taken at an accepted average value, it may be determined by any well known method. For instance, if the material is dry, a known weight (in grams) of the material under examination is placed in the flask, and water added to the mark (in the suggested flask to the top), the total weight of the contents is then taken. The density is obtained by the use of formula (1). Wet material, such as mill-pulp, is preferably dried and weighed after the determination of the specific gravity of the pulp.



In practice it has been found that flasks having a large mouth ground true, the ground edge to be used as the mark of capacity, are more convenient for taking fair samples than the usual glasses with a mark below the mouth. In consequence of sand adhering to the glass above the mark, the latter are more difficult to fill accurately.

2. Determination of Specific Gravity of Pulps

Almost all factors determining the nature of pulps, from the millman's point of view, are governed by the specific gravity of the pulp. If the metric system of weights be used, the specific gravity is at once obtained by dividing the net weight

*Extract from the Jour. Chem., Met. and Min. Soc. of South Africa, November, 1911.

[1]The Mining Magazine, Vol. 1, Nov. and Dec., 1909.
[2]See F. B. Hyder's 'Specific Gravity Estimation of Pulp,' Colorado Scientific Society, Vol. IX, p. 417; and W. A. Caldecott, Jour. Chem., Met. and Min. Soc. of S. A., Vol. 11, p 375.

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of the pulp by the volume occupied, or when a 1000-c.c. flask is used by cutting off the last three decimals of the net weight of the pulp (in grams). The specific gravity of slime pulp, in which all solids are freely suspended, may be measured by a hydrometer.

3. Determination of Percentage (By Weight) of Dry Solid and Water

Although the specific gravity is indicative of the constitution of pulps, the percentage of dry solid or moisture conveys a more definite impression to the average mind. The usual method of determining the percentage of solids and moisture, by drying and weighing, is very troublesome, and also, as done in practice, unreliable and inaccurate. Hence methods based on specific gravity, formula (3), are vastly quicker and more convenient.

Any alteration in the composition and in the rate of flow of pulps shows itself by a marked change in the percentage of moisture and this therefore gives a reliable, sensitive, and effective control in the uniform distribution of the pulp and the regular working of classifiers. For instance, at a mine where a set of eight similar classifiers was fed with the same battery pulp, the moisture in the underflow of the different classifiers varied, at the same moment, from 35 to 75%, thus showing that the distribution of the pulp over the classifiers was very irregular. It is to be hoped that, with such a convenient means at hand, millmen will pay more attention to the control of individual units, as the total average always gives figures which are no help in detecting faulty work.

4. Tonnage Measurements of Total Pulps (Tp) and of Dry Solid in Pulps (Ts)

Tonnage measurements of flowing quantities are generally made by running pulp for a measured time into a vessel of sufficient capacity to give fairly accurate results. Scales for weighing the large quantities collected are not practically available, and the drawing off of the water, drying and weighing of the solid portion in such quantities still less practicable. All these inconveniences are avoided by reckoning the tonnage from the volume occupied by the total pulp (in cubic feet) and its specific gravity, by formula (4) for the total pulp, and by formula (5) for the dry solid portion only.

The simplest manner to carry out these measurements is to run the pulp into a box of known capacity, large enough to take at least one minute's run of the stream. The exact time required for filling is taken by a stop-watch, the point of overflow being easily and exactly determinable. The specific gravity is determined from separate representative samples taken simultaneously, and the calculated weight of pulp or dry slime passing during the time (t in seconds) are then used to give the hourly or daily quantities. If, in all measurements, boxes of equal capacity are used, for instance, 16 cu. ft. (the volume of half a ton of water), all the constant factors may be condensed into one. For a box of the above capacity the formulæ for Rand ore are:

$$\text{Tons of total pulp in 24 hours: (Tp)} = \frac{43{,}200p}{t}$$

$$\text{Tons of dry solids only (Ts)} = \frac{(p-1)\ 68609}{t}$$

Since the capacities of launders, vats, pumps, and other machines, as well as the rates of overflow of classifiers are determined by the volume of the pulp, the fluid ton of 32 cu. ft. (equal to the volume of 2000 lb. water, on the assumption that 1 cu. ft. of water weighs 62.5 lb.) is frequently used as a unit in mining work. The tonnage of pulps of known specific gravities is readily converted into fluid tons by formula (7) for the total pulp and by formula (9) for the dry solid portion.

The same method is also applicable on a large scale to the tonnage measurement of vats, provided the consistence of the pulp is not changed by drawing off water or slime (as is the case with sand-collecting and slime-settling vats), or by adding cyanide solution (as happens with slime-treatment vats). For large measurements the practical utility of this method is therefore confined to agitation or circulating-vats, and in all other cases, for lack of better methods, resort must be had to the method commonly practiced, inaccurate as it is, of estimating the dry solid by the established dry weight of the settlement volume. This varies considerably with the nature and the fineness of the ore, and should therefore be checked frequently and corrected if necessary by actual test. For such tests the method I describe is suitable, as no drawing off of water nor drying is necessary.

At the Knight Central G. M. Co. the daily tonnage measurements of the mill-pulp for several years past have been regularly taken by the gravity method, which, after careful investigation, was found to give most reliable results. In addition there is the advantage that it can be carried out without waiting for settlement of the slime. After filling the first transfer tank with solution and after circulation (the whole operation taking about four hours), two samples are taken, one at the delivery pipe, representing the pulp at the bottom of the tank, and one from the upper part, to get a representative average for the whole content.

5. Relations of Flowing Quantities in Classifiers

The relation of flowing quantities in classifiers may be calculated from the percentage of any of their components measured at the inflow, overflow, and underflow. No component can so quickly and reliably be measured as the percentage of dry solid taken with the specific gravity flask. From the percentages of dry solid so obtained, the tonnage of the total pulp underflow (as a percentage of the total pulp inflow) is calculated by formula (10) and the tonnage of dry solid underflow (as a percentage of dry solid inflow) by formula (11). In either case it is first necessary to calculate the percentage of solid, since the flowing quantities of the underflow can directly be determined from the values of the specific gravity, by formula (12) to get the percentage of the total pulp, and by (13) to get that of the dry solid portion only. The accuracy obtainable by the specific gravity method is only limited in practice by the accuracy with which the means at our disposal determine the correct values of (1) the volumetric weight of the pulp (w), (2) the density of the solid (d), and (3) the specific gravity of the liquid (δ).

(1). **Accuracy of Volumetric Weight of Pulp.**—When using a 1000-c.c. flask an error in content or in weighing of even 10 c.c. or 10 gm. respectively, affects the specific gravity (p) of the pulp in the third decimal only. For a 1:1 pulp (Rand ore)

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gives an absolute error of 0.74% in the calculation of the dry solid or moisture percentages, corresponding to 1.48% of the true value. With the dilution of the pulp the error increases progressively. The accuracy of the tonnage measurement of the total pulp varies as that of (p), while the tonnage of the dry portion shows an error of 2.17% which increases progressively with the dilution of the pulp. If we allow such rough work in actual mining practice, the annexed curve gives us the percentage of moisture or solid within ½ to 1 per cent.

(2). **Accuracy of Density of Solid.**—It seems that the average density of Rand ore is, at least for individual mines, fairly steady. The constant (k) in the formula varies with the density as follows:

Density ..	2.4	2.5	2.6	2.7	2.8	2.9	3.0
k	171.4	166.6	162.5	158.8	155.5	152.6	150.0

A variation from the generally accepted average density of 2.7 for Rand ore to 2.8 affects the accuracy of the specific gravity (p) in a 1:1 pulp by 0.96%, which error decreases slowly with the dilution of the pulp. The tonnage of the total pulp is affected to the same extent as (p), while the dry solid portion shows a constant error of 2.8% independently of the consistence of the pulp. For the percentage of dry solid and moisture the error is 2.06%, which increases with the dilution of the pulp. When much concentration of the pyritic portion of the ore takes place the actual specific gravity must be ascertained in each case, as an increase from 5 to 10% pyrite causes the specific gravity of the solid to vary from 2.7 to about 2.8 per cent.

(3). **Accuracy of Specific Gravity of Liquid.**—All the formulæ are based on the specific gravity of pure water, but they are applicable to ordinary mixtures of cyanide solutions with enough accuracy for practical purposes, except in cases of excessively thin pulps, such as turbid water, overflow of classifying vats, etc. For exact scientific work or for much heavier liquids (sea water = 1.027) the true specific gravity (δ), corrected for temperatures, is taken into consideration in the following formulæ:

$$\text{Specific gravity of pulp} = \frac{100\,\delta p}{100d - S(d-\delta)}, \text{ and}$$

$$\text{Percentage of dry solid } S = \frac{100\,d(p-\delta)}{p(d-\delta)}$$

In stating that the extent of the error introduced by ignoring the higher specific gravity of cyanide solutions, is not generally appreciated, Mr. Hyder was misled by erroneous information (accepted by him with the reservation "assuming this to be correct") as to the average density of ordinary cyanide solutions. This strength does not generally exceed 0.18% for sand, 0.025% for slime, and 0.3% for black sand. I am indebted to M. T. Murray, lecturer of the South African School of Mines, for the exact determinations of the specific gravity of an ordinary cyanide solution, assaying 0.126% KCN and 0.01% alkalinity. He obtained a value of 1.0021, and from the data given above it will be seen that the small variation from the specific gravity of pure water is negligible. These results are published through the courtesy of the Mines Trial Committee though on my own responsibility.

NOTES ON AIR LIFTS

The Construction and Operation of Air-Lifts

Not long ago a well-known practical mill man, who was being shown around a mill, then in course of erection, commented on the air-lifts. His advice was to discard them, and replace by some kind of pump or elevator. His own experience had been unfavorable. The man who was to take charge of the mill, as foreman, was also dubious; the experience he had had with them, working under another engineer was not satisfactory.

Again, in one of the most up-to-date mills on the continent—one in which the practice was carefully worked out by several years' preliminary work on a smaller mill—the air-lift is conspicuous by its absence. All wet pulp is raised by bucket-elevator. These brief statements outline the general attitude towards air-lifts. Some engineers are more than a little afraid of them. It is, however, interesting to note that in the mill first referred to, the air-lift worked most successfully, and that, in the latter, a modification in the treatment required elevation of the pulp in a part of the mill where no provision was made for such elevation; an air-lift was tried out and worked so successfully and economically that the present intention is to replace the bucket-elevator by air-lift wherever possible.

There have been many failures in the use of air-lifts for elevating pulp. Nothing is heard of these failures, owing to the fact that most of them were on a small or experimental scale. It is clear, then, that the principles on which the pulp-air-lift works are not well, or generally, understood. The practice in lifting pulp differs in certain particulars from the air-lift which merely raises water. The failures are due to not appreciating these differences.

In regard to the principles on which air-lifts work there is still a general misapprehension among mill men. Many believe that the liquid is raised in the lift pipe by the medium of "pistons" of air thrusting the fluid upwards. In a properly designed and operated air-lift, this is incorrect. In a well-arranged lift the flow of pulp is steady and even, showing that pistons of air do not occur. When the pulp is delivered in spurts, the air-lift is working inefficiently.

The air-lift merely works on the principle of the hydrostatic balance; the fluid in one limb being lightened by the introduction of air. For example, take a U tube, 4 ins. in diameter, with one limb 24 ft. long, and the other 36 ft.; it will hold about 4 cu. ft. above the bend. Now into the long limb of the U tube pass a stream of air bubbles, so that all times there is one cu. ft. of air in it. Each sphere of air will displace an equivalent volume of water, and of course the water will rise in the long limb until the volume is that of the combined air and water; or in this case it will rise 12 ft. without in any way affecting the water level in the short

*A. M. Merton in Mining and Eng. World.

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limb. Thus we see that 24 ft. of water will balance 36 ft. of an aerated fluid containing 30% of air by volume. Now if the long limb is cut 6 ft. below the top of the pipe, the water will flow out under a head of 6 ft. (or with an initial pressure of about one-fifth pound per square inch in this case) until the level stands 4 ft. lower in the short limb, when the flow will cease. Thus we have again 20 ft. of water balancing 30 ft. of mixed water and air, and if the short limb is continuously supplied with water, the longer limb will have a steady stream of water issuing from it. There is no necessity whatever to assume the presence of air pistons. The little bubbles of air displacing an equivalent volume of water are not only sufficient to do the work, but experience has shown that they act more economically than the pistons.

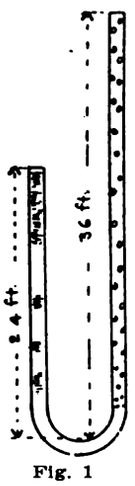

Fig. 1

Fig. 2

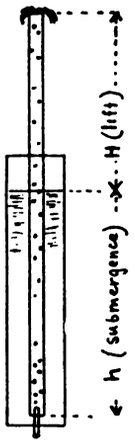

Fig. 3

All this is rudimentary, but it must be understood, if clear ideas are to be held regarding air lifts. But in air lifts for elevating pulp, other questions have to be considered. To neglect these questions is to invite failure.

Pulp is a mixture of sand, clay and water, or cyanide solution. It is clear that, in raising such a mixture, the velocity upwards must be great enough to lift the coarsest particles in the pulp. Otherwise there will be a sorting action in the lift—the lighter particles being carried upwards and the coarser left behind—and the gradual accumulation at the bottom of the pipe will eventually choke it.

The operation of an air-lift discloses the fact that the screens and classifiers of a mill allow, in some manner, the escape of a very small percentage of very coarse particles. For instance, in one plant treating 4500 tons of slime a month, 80% of the slime passing a 150-mesh screen, there accumulated, in one part of the system, about 1000 lbs. of coarse ore every month. Or at least that amount was removed. There was reason to believe that the actual amount present was greater. The particles varied in size from rice, to a small bean. Screen analyses never detected their presence.

In considering air-lifts, therefore, the upward velocity of the current must be great enough to carry off very large pieces of ore, otherwise the air-lift will give periodical trouble by choking. Considerable experience with air-lifts has shown that the velocity of the pulp in the rising limb must not be less than 2½ ft. per second and that to get good results 5 ft. per second would be better.

In every case of a failure of which I have any specific knowledge, the fault has been in having too large a rising pipe. A large pipe, in carrying water, of course, means a low loss by friction; but it also means a low velocity of water in the pipe. In an air-lift elevating pulp, the velocity upwards is fixed by the character of the pulp and cannot be reduced. The loss due to friction cannot be eliminated.

The next error is in providing insufficient air to properly operate the lift. Mechanically the air-lift is most inefficient. Generally 3 times as much air is required to raise a given quantity than is theoretically necessary. It is safe to say that twice the amount of air is required to lift a mill pulp than the tables give for lifting an equivalent amount of water. Of course, it is to be understood that these statements are approximations.

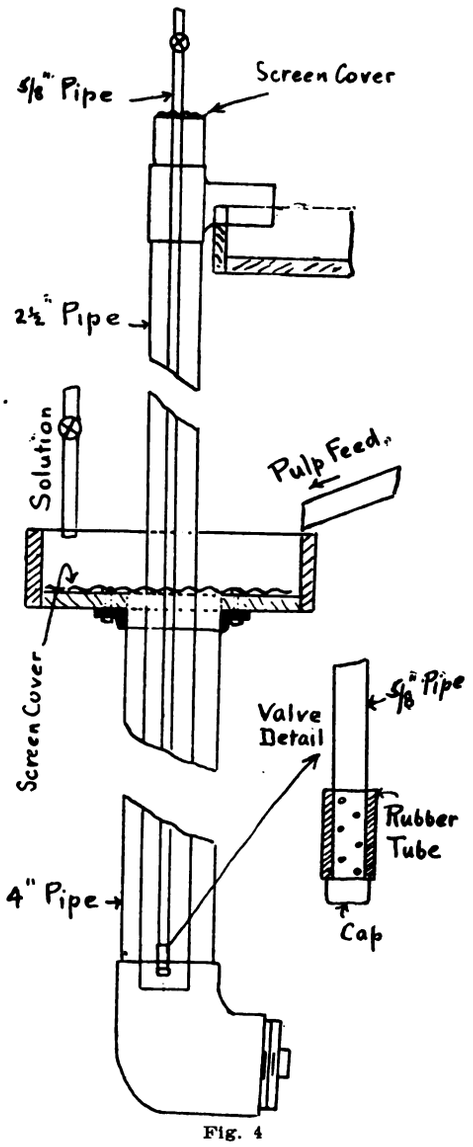

Fig. 4

Requirements of An Air-Lift

Turning now from general considerations, let us consider the specific requirements of an economical air-lift:

Usually the air-lift takes the form of 2 tubes, one within the other. The outer pipe acts as a well, while the small inner pipe acts as the riser, and takes the place of the long limb in the U-tube.

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In the diagram (Fig. 3) H is the height of lift; h is the feet of submergence; H plus h is the total length of the riser. It has been found by experience that h should be at least 60% of the quantity H plus h, to get economical results. In actual mill work it can be as low as 45%.

The air pressure required is calculated from the formula:

P=pressure;
S.G.=specific gravity of pulp;
h=submersion.

P=433 S.G., h.

Actually a few pounds extra pressure are required to overcome friction, say from 3 to 4 lbs.

The amount of air required depends upon the design of the lift and the percentage of submersion. Too few data are at hand to safely theorize upon this matter. Actual test has shown that 2.5 cu. ft. of free air per cubic foot of pulp to be raised is the least that should be provided. In a specific case 3.2 cu. ft. air were required to raise 1 cu. ft. of a pulp containing 28% solids. For a new plant where actual data are wanting it is safe to say that a compressor capacity of 3.5 cu. ft. of free air by piston displacement per cubic foot of pulp to be raised the least that should be provided.

In selecting a compressor it is a mistake to have too high a pressure. If the requirements are for 20 lbs. pressure, the delivery of air at 30 lbs. is mere waste of power. It has been said that an air-receiver is not necessary. This may be so, theoretically. Still a large receiver is necessary when the air is being used for a great variety of purposes. Also, practically, it acts as an oil trap, the value of which, in a cyanide or concentration plant, cannot be gainsaid. There are air-cooled compressors on the market for low-pressure air. These have been used with satisfaction, but often they consume too much oil to be good machines for metallurgical purposes.

Lastly, in considering mill work it should be remembered that the requirements for economy cannot be strictly followed. Where there are a number of lifts, agitators, etc., to be operated from the same compressor, the requirements of each must be different. Thus one may only require 10 lbs. pressure while another may demand 28 lbs.

The efficiency of air-lifts has been reckoned to be from 40 to 50%. In actual practice the economy can only be reckoned as about 35%. Especially where many lifts working under different heads are joined up to the same compressor.

However, in spite of the low mechanical efficiency, the absence of moving parts, the cheapness of the material used, and the compactness of the apparatus all make the well-designed air-lift the most economical means of lifting pulp that we now have.

The actual design and construction of an air-lift should be as simple as possible. Elaborate designs for maintaining a uniform submergence, by regulating the air inlet by means of floats, etc., are valueless. This may be, indeed, a detriment. Complicated foot-valves for delivery of the air at the bottom of the riser, are also not only unnecessary, but frequently are a nuisance.

So far as the air-jet is concerned, it may simply be formed by the open end of the pipe looking downwards. Where the attempt is made to use the air as a jet, as in an injector, there is always bother when the plant is closed down. The upward nozzle fills with slime, forming a plug, which even high-pressure air will not always expel. Then the messy and disagreeable task of opening the bottom of the lift is before the mill men. The value of low pressure air as a jet is probably negligible. The simple valve formed by a piece of rubber tube at the end of the air-pipe is as effective as any of the more complicated jets, etc.

In the design given every requirement of actual operation is met fairly well. It need only be stated that, when closing down the mill temporarily, a good deal of trouble can be avoided by shutting off the flow of pulp to the lift, and turning on a flow of water or solution. The slime, at least, is washed out and the lift can be easily started again.

The practical mill man opens up the lift before sending a flow of pulp to it, using the water or solution instead, to insure the fact that there is no stoppage. Then the stamps can be dropped with assurance that the pulp will be taken care of.

The following table shows the requirements of various volume of pulp. Those marked with an asterisk are details from actual cases. The capacities of the various lifts are approximations for submergences of 45 to 60%. Under practical conditions, the submergence is constantly fluctuating. If the submergence is increased (owing possibly to an increased rate in the feed of pulp) the capacity of the lift is increased, and the air consumption will be diminished, and vice versa when the submergence is decreased.

AIR LIFT DATA

Rising main.	Well pipe.	Air pipe.	Pulp cap. Cu. ft. per min.	Free air required. Cu. ft. per min.
	Ins. diam.			
*1	2½	⅜	1.25	4
1½	3	⅜	3.50	11
*2	4	½	6.60	20
2½	4	⅝	10.00	30
*3	5	¾	15.00	50

Test—A 3-in. air lift, submersion 50%, Pulp 28% solids, gave delivery of 1200 lbs. pulp (15.5 cu. ft.) and consumed 48 cu. ft. air per minute.

Air-Lift Drawbacks

Air-lifts have their drawbacks. First there is the submergence to be provided for. In a flat mill site, this is a serious matter. In a terraced mill, part or the whole of the submergence can be obtained at the edges of the benches. Also they do not accommodate themselves to very wide ranges of capacity. For example, if in a 20-stamp mill one lift is provided for all stamps, when 3 of the batteries are hung up, the lift will probably not work well on the small amount of pulp delivered by 5 stamps only. The remedy of having 2 lifts in this case, is obvious.

A well-designed lift intelligently operated, is safe, simple and economical. But mill men must understand that an air-lift cannot be made by putting together 3 pipes one inside the other. The conditions mentioned must be fulfilled; when they are, an air-lift is by long odds the best pulp elevator we have; when they are not, it is an abomination.

AVERAGE CAPACITY OF AIR LIFTS

Diam. of Lift Pipe	Cu. Ft. per Minute	Tons per 24 hours with fluid of sp. gr. 1.0	1.1	1.2	1.3	1.4	1.5
2	6	270	297	324	351	378	405
2½	10	450	495	540	585	630	675
3	14	630	693	756	819	882	945
3½	20	900	990	1080	1170	1260	1350
4	25	1125	1237	1350	1462	1575	1687
5	40	1800	1980	2160	2340	2520	2700
6	56	2520	2776	3024	3276	3528	3780

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SLIME DENSITY RELATIONS*

The table is based on the percentage of solid in the slime, opposite which is given the ratio of solid to liquid. The numbers heading the double columns following, are the specific gravities of the dry solid (that of water being taken as unity). The columns headed S. G. show the specific gravities of the slime, that of water being taken as 1000; that is, the figures show directly the weight of a liter of slime in grams. The columns headed Vol. show the number of cubic feet of the slime in one ton of 2000 pounds.

The specific gravities of solids chosen will probably cover the range of slimes ordinarily met with and the intervals are sufficiently small to admit of interpolation without appreciable error. The last column (4.50) is a hypothetical concentrate and is the specific gravity of a mixture of 80 per cent. pyrite and 20 per cent. quartz. The average specific gravity of working cyanide solutions is so small as to be negligible.

The table is convenient for ascertaining the amount of solid and of solution in slime pulps from the number of cubic feet, determined by rod or float, in the tank; and specific gravity of the slime, determined by taking the weight of a liter or by a specific gravity indicator in the tank. It is useful in calculations for ascertaining the amount of solution to be abstracted or added in thickening and diluting, for correcting the strength of the solutions, for checking tonnage and for other purposes.

Assume that in a plant in which the specific gravity of the solid is 2.7, a tank is shown, by the depth of pulp in it, to contain 3530 cubic feet of pulp, a liter of which weighs 1223 grams. From the table it is found that the specific gravity 1223 corresponds to 26.16 cubic feet per ton and to 29 per cent. solid. The weight of pulp, therefore, is 3530÷26.16=135 tons and the weight of solids 135 ×0.29=39.15 tons. The weight of solution is, by difference, 95.85 tons. If the solution titrates 1.05 pounds cyanide per ton and it is desired to bring the strength up to 2.5 pounds per ton, we have 2.5—1.05=1.45 pounds cyanide to be added per ton. Therefore, 95.85×1.45=139 pounds cyanide to be added to the tank.

The table is useful in determining the sizes of tanks necessary for any given capacities. Thus, if it is desired to agitate 50 tons of dry slime (specific gravity of solid 2.6) with three parts solution, the table shows this to contain 25 per cent. solids and to have a volume of 27.08 cubic feet per ton; therefore, 50÷0.25=200 tons of slime×27.08=5416 cubic feet, the required effective working capacity of the tank, to which an amount must be added to secure the desired height of curb above the charge.

*Lowden in Metallurgical and Chemical Engineering, June, 1912.

Per Cent. Solids.	Ratio of Solids to Solution.	Specific Gravity of Pulp and Volume of One Ton in Cubic Feet, for Slimes Containing Solids of Different Specific Gravities. 2.50 S.G.	2.50 Vol.	2.60 S.G.	2.60 Vol.	2.70 S.G.	2.70 Vol.	2.80 S.G.	2.80 Vol.	2.90 S.G.	2.90 Vol.
5	1:19.000	1031	31.03	1032	31.01	1032	31.01	1033	30.97	1034	30.95
6	1:15.667	1037	30.85	1036	30.82	1039	30.79	1040	30.76	1041	30.74
7	1:13.286	1044	30.66	1045	30.62	1046	30.59	1047	30.56	1048	30.53
8	1:11.500	1050	30.46	1052	30.43	1053	30.39	1055	30.36	1056	30.32
9	1:10.111	1057	30.27	1059	30.23	1060	30.19	1061	30.15	1063	30.11
10	1: 9.000	1064	30.08	1065	30.03	1067	29.99	1068	29.95	1070	29.90
11	1: 8.091	1071	29.88	1073	29.83	1074	29.79	1076	29.74	1078	29.69
12	1: 7.333	1078	29.70	1080	29.64	1082	29.59	1083	29.53	1085	29.48
13	1: 6.692	1085	29.50	1087	29.44	1089	29.39	1091	29.33	1093	29.27
14	1: 6.144	1092	29.31	1094	29.24	1097	29.19	1099	29.12	1101	29.06
15	1: 5.667	1099	29.18	1102	29.05	1104	28.99	1107	28.91	1109	28.85
16	1: 5.250	1106	28.93	1109	28.85	1112	28.78	1115	28.71	1117	28.65
17	1: 4.882	1114	28.74	1117	28.65	1119	28.58	1123	28.50	1125	28.44
18	1: 4.556	1121	28.54	1125	28.45	1128	28.38	1131	28.30	1134	28.23
19	1: 4.263	1129	28.35	1133	28.26	1136	28.18	1139	28.09	1142	28.02
20	1: 4.000	1136	28.17	1140	28.06	1144	27.98	1147	27.89	1151	27.81
21	1: 3.762	1144	27.97	1148	27.87	1152	27.77	1156	27.68	1159	27.60
22	1: 3.545	1152	27.78	1157	27.67	1161	27.57	1165	27.47	1168	27.39
23	1: 3.348	1160	27.58	1165	27.47	1169	27.37	1174	27.27	1177	27.18
24	1: 3.167	1168	27.39	1173	27.27	1178	27.17	1182	27.06	1186	26.97
25	1: 3.000	1176	27.21	1182	27.08	1187	26.97	1191	26.85	1195	26.76
26	1: 2.846	1185	27.01	1190	26.88	1195	26.77	1201	26.65	1205	26.55
27	1: 2.704	1193	26.82	1199	26.68	1205	26.56	1210	26.44	1215	26.84
28	1: 2.571	1202	26.62	1209	26.49	1214	26.36	1220	26.24	1224	26.13
29	1: 2.448	1211	26.43	1217	26.29	1223	26.16	1229	26.03	1234	25.92
30	1: 2.333	1220	26.24	1226	26.10	1233	25.95	1239	25.83	1244	25.71
31	1: 2.226	1229	26.05	1236	25.90	1242	25.75	1249	25.63	1255	25.50
32	1: 2.125	1238	25.86	1245	25.70	1252	25.55	1259	25.42	1265	25.29
33	1: 2.030	1247	25.66	1255	25.50	1262	25.35	1269	25.21	1276	25.08
34	1: 1.940	1256	25.47	1264	25.31	1272	25.15	1279	25.01	1287	24.87
35	1: 1.857	1266	25.28	1274	25.12	1283	24.95	1290	24.80	1298	24.66
36	1: 1.778	1276	25.09	1284	24.91	1293	24.75	1301	24.60	1309	24.45
37	1: 1.703	1285	24.90	1295	24.71	1304	24.55	1312	24.39	1320	24.24
38	1: 1.632	1295	24.70	1305	24.52	1314	24.35	1323	24.19	1332	24.03
39	1: 1.564	1305	24.51	1316	24.32	1326	24.14	1335	23.98	1343	23.82
40	1: 1.500	1316	24.32	1326	24.13	1336	23.95	1346	23.77	1355	23.61
41	1: 1.439	1326	24.13	1337	23.93	1348	23.74	1357	23.57	1367	23.40
42	1: 1.381	1337	23.94	1348	23.73	1359	23.55	1370	23.36	1380	23.19
43	1: 1.326	1348	23.74	1359	23.53	1371	23.34	1382	23.16	1392	22.99
44	1: 1.273	1359	23.55	1372	23.33	1383	23.15	1395	22.95	1405	22.78
45	1: 1.222	1370	23.36	1383	23.14	1395	22.94	1407	22.74	1418	22.57
46	1: 1.174	1381	23.17	1395	22.94	1408	22.73	1420	22.54	1432	22.36
47	1: 1.128	1393	22.98	1407	22.75	1420	22.54	1433	22.33	1445	22.15
48	1: 1.083	1404	22.78	1419	22.55	1433	22.33	1446	22.12	1458	21.94
49	1: 1.041	1416	22.59	1431	22.35	1446	22.13	1460	21.92	1473	21.73
50	1: 1.000	1429	22.39	1444	22.15	1460	21.92	1473	21.71	1487	21.52
51	1: 0.961	1441	22.21	1458	21.96	1473	21.72	1488	21.51	1502	21.31
52	1: 0.923	1453	22.02	1471	21.76	1487	21.52	1502	21.30	1517	21.10
53	1: 0.887	1466	21.82	1484	21.56	1501	21.32	1516	21.10	1532	20.89
54	1: 0.852	1479	21.63	1498	21.36	1515	21.12	1532	20.89	1548	20.68
55	1: 0.809	1493	21.44	1512	21.17	1530	20.92	1547	20.69	1564	20.47
56	1: 0.786	1506	21.25	1526	20.97	1545	20.72	1563	20.48	1580	20.26
57	1: 0.754	1520	21.06	1540	20.77	1560	20.51	1579	20.27	1596	20.05
58	1: 0.724	1534	20.86	1555	20.58	1574	20.31	1595	20.07	1613	19.84
59	1: 0.695	1548	20.67	1572	20.38	1591	20.11	1611	19.86	1629	19.63
60	1: 0.667	1563	20.48	1585	20.18	1607	19.91	1628	19.66	1645	19.42
61	1: 0.639	1577	20.29	1601	19.98	1623	19.71	1645	19.45	1664	19.21
62	1: 0.613	1592	20.10	1617	19.79	1641	19.51	1662	19.25	1683	19.00
63	1: 0.587	1608	19.90	1633	19.59	1657	19.30	1681	19.04	1703	18.79
64	1: 0.563	1623	19.71	1650	19.40	1675	19.10	1698	18.94	1723	18.58
65	1: 0.538	1639	19.52	1667	19.20	1692	18.90	1718	18.73	1742	18.37
66	1: 0.515	1656	19.32	1684	19.00	1711	18.70	1738	18.53	1762	18.16
67	1: 0.493	1672	19.14	1701	18.80	1730	18.50	1757	18.32	1783	17.95
68	1: 0.471	1689	18.94	1719	18.61	1749	18.30	1776	18.11	1803	17.74
69	1: 0.449	1706	18.75	1738	18.41	1768	18.10	1797	17.81	1825	17.53
70	1: 0.429	1724	18.56	1757	18.21	1786	17.90	1818	17.60	1847	17.32

Per Cent. Solids.	Ratio of Solids to Solution.	Specific Gravity of Pulp and Volume of One Ton in Cubic Feet, for Slimes Containing Solids of Different Specific Gravities. 3.00 S.G.	3.00 Vol.	3.10 S.G.	3.10 Vol.	3.20 S.G.	3.20 Vol.	3.30 S.G.	3.30 Vol.	*4.50 S.G.	*4.50 Vol.
5	1:19.000	1035	30.93	1035	30.92	1036	30.90	1036	30.89	1040	30.76
6	1:15.667	1042	30.72	1042	30.70	1043	30.68	1043	30.66	1049	30.51
7	1:13.286	1049	30.51	1049	30.48	1050	30.46	1051	30.43	1058	30.26
8	1:11.500	1056	30.30	1057	30.27	1058	30.24	1059	30.21	1067	30.01
9	1:10.111	1064	30.09	1065	30.05	1066	30.02	1067	29.99	1075	29.76
10	1: 9.000	1071	29.87	1072	29.83	1074	29.80	1075	29.77	1084	29.51
11	1: 8.091	1078	29.65	1080	29.61	1082	29.58	1083	29.54	1093	29.26
12	1: 7.333	1087	29.44	1088	29.40	1090	29.36	1091	29.32	1102	29.01
13	1: 6.692	1095	29.23	1096	29.18	1098	29.14	1099	29.10	1112	28.76
14	1: 6.144	1103	29.01	1105	28.96	1106	28.92	1108	28.88	1122	28.52
15	1: 5.667	1111	28.80	1113	28.74	1115	28.70	1117	28.66	1132	28.27
16	1: 5.250	1119	28.59	1122	28.53	1124	28.48	1125	28.43	1142	28.02
17	1: 4.882	1128	28.37	1130	28.31	1132	28.26	1134	28.21	1152	27.77
18	1: 4.556	1136	28.16	1139	28.10	1141	28.04	1143	27.99	1163	27.52
19	1: 4.263	1145	27.95	1148	27.88	1150	27.82	1153	27.76	1173	27.27
20	1: 4.000	1154	27.73	1157	27.66	1159	27.60	1162	27.54	1184	27.02
21	1: 3.762	1163	27.52	1166	27.44	1169	27.38	1171	27.32	1194	26.77
22	1: 3.545	1172	27.31	1175	27.23	1178	27.16	1181	27.09	1206	26.52
23	1: 3.348	1181	27.09	1184	27.01	1188	26.94	1191	26.87	1218	26.28
24	1: 3.167	1190	26.88	1194	26.79	1198	26.72	1201	26.65	1230	26.03
25	1: 3.000	1200	26.67	1204	26.58	1208	26.50	1211	26.42	1241	25.78
26	1: 2.846	1210	26.45	1214	26.37	1218	26.28	1222	26.20	1253	25.53
27	1: 2.704	1220	26.24	1224	26.15	1228	26.06	1232	25.98	1266	25.28
28	1: 2.571	1230	26.03	1234	25.93	1239	25.84	1242	25.75	1278	25.03
29	1: 2.448	1240	25.81	1244	25.71	1249	25.62	1253	25.53	1291	24.78
30	1: 2.333	1250	25.60	1255	25.50	1260	25.40	1264	25.31	1304	24.53
31	1: 2.226	1261	25.39	1266	25.28	1271	25.18	1275	25.08	1317	24.28
32	1: 2.125	1271	25.17	1277	25.06	1282	24.96	1287	24.86	1331	24.04
33	1: 2.030	1282	24.96	1288	24.85	1293	24.74	1299	24.64	1345	23.79
34	1: 1.940	1293	24.75	1299	24.63	1305	24.52	1311	24.41	1359	23.54
35	1: 1.857	1304	24.53	1310	24.41	1317	24.30	1323	24.19	1374	23.29
36	1: 1.778	1316	24.32	1322	24.19	1329	24.08	1335	23.97	1389	23.04
37	1: 1.703	1328	24.11	1334	23.98	1341	23.86	1347	23.75	1404	22.79
38	1: 1.632	1340	23.89	1346	23.76	1353	23.64	1360	23.52	1420	22.54
39	1: 1.564	1351	23.68	1358	23.55	1366	23.42	1373	23.30	1435	22.29
40	1: 1.500	1363	23.47	1371	23.33	1379	23.20	1387	23.08	1451	22.04
41	1: 1.439	1376	23.26	1384	23.11	1393	22.98	1400	22.85	1468	21.79
42	1: 1.381	1389	23.04	1397	22.89	1406	22.76	1414	22.63	1485	21.55
43	1: 1.326	1402	22.83	1411	22.68	1419	22.54	1428	22.41	1502	21.30
44	1: 1.273	1416	22.61	1425	22.46	1433	22.32	1442	22.18	1519	21.05
45	1: 1.222	1429	22.40	1438	22.24	1447	22.10	1456	21.96	1538	20.80
46	1: 1.174	1443	22.19	1452	22.02	1462	21.88	1471	21.74	1557	20.55
47	1: 1.128	1457	21.97	1467	21.81	1477	21.66	1487	21.51	1576	20.30
48	1: 1.083	1471	21.76	1483	21.60	1493	21.44	1503	21.29	1595	20.05
49	1: 1.041	1485	21.55	1497	21.38	1508	21.22	1519	21.07	1615	19.81
50	1: 1.000	1500	21.33	1512	21.16	1524	21.00	1535	20.85	1637	19.56
51	1: 0.961	1515	21.12	1528	20.94	1540	20.78	1551	20.62	1658	19.31
52	1: 0.923	1531	20.91	1544	20.73	1556	20.56	1568	20.40	1679	19.06
53	1: 0.887	1547	20.69	1560	20.51	1573	20.34	1585	20.18	1700	18.81
54	1: 0.852	1563	20.48	1577	20.29	1590	20.12	1603	19.96	1724	18.56
55	1: 0.809	1579	20.27	1594	20.08	1608	19.90	1621	19.73	1748	18.31
56	1: 0.786	1596	20.05	1611	19.87	1626	19.68	1640	19.51	1772	18.06
57	1: 0.754	1613	19.84	1628	19.65	1645	19.46	1659	19.29	1796	17.81
58	1: 0.724	1631	19.63	1646	19.43	1663	19.24	1678	19.06	1822	17.56
59	1: 0.695	1649	19.41	1665	19.21	1682	19.02	1697	18.84	1848	17.32
60	1: 0.667	1667	19.20	1684	19.00	1702	18.80	1718	18.62	1875	17.07
61	1: 0.639	1686	18.99	1704	18.78	1722	18.58	1739	18.39	1903	16.82
62	1: 0.613	1705	18.77	1724	18.56	1742	18.36	1761	18.17	1932	16.57
63	1: 0.587	1724	18.56	1745	18.34	1764	18.14	1783	17.95	1961	16.32
64	1: 0.563	1745	18.35	1765	18.12	1786	17.92	1805	17.72	1992	16.07
65	1: 0.538	1765	18.13	1786	17.91	1808	17.70	1828	17.50	2023	15.82
66	1: 0.515	1786	17.92	1808	17.69	1830	17.48	1852	17.28	2054	15.57
67	1: 0.493	1808	17.71	1831	17.47	1853	17.26	1876	17.06	2088	15.32
68	1: 0.471	1830	17.49	1854	17.26	1877	17.04	1901	16.83	2123	15.08
69	1: 0.449	1852	17.28	1878	17.04	1902	16.82	1927	16.61	2159	14.83
70	1: 0.429	1875	17.07	1902	16.83	1926	16.60	1953	16.39	2195	14.58

* 80 per cent pyrite and 20 per cent. quartz.

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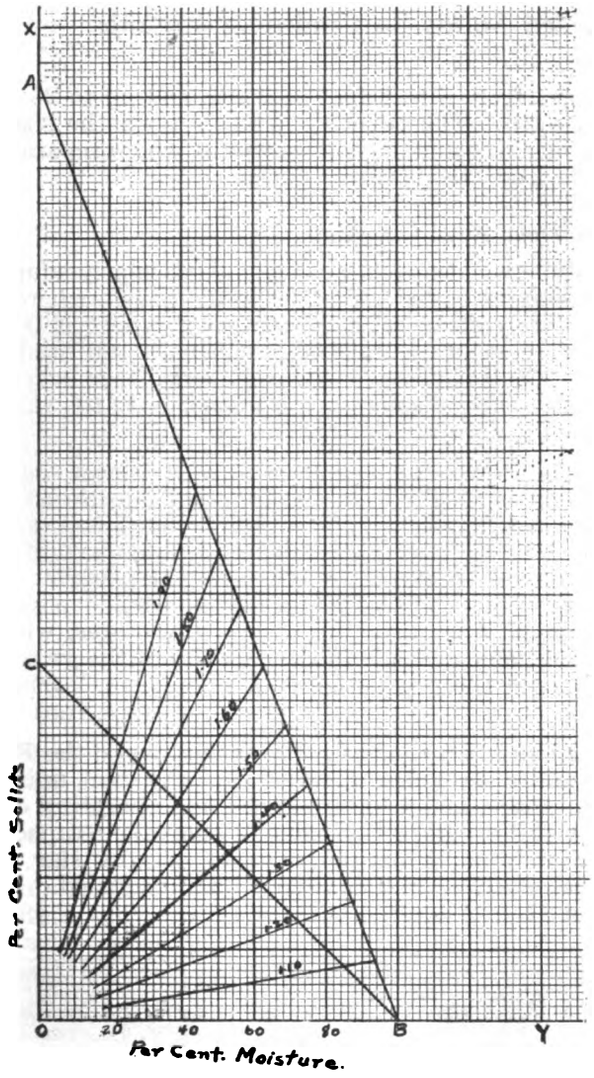
SPECIFIC GRAVITY CHART

Frequently in cyanidation, when slime is being handled, the percentage of moisture and the percentage of solids in the pulp must be known in order to determine the proper treatment. The common practice is to determine their quantities from the specific gravity determinations, which are taken at frequent intervals during the day. Most moisture percentage charts involve curves and are to a certain extent puzzling. They are constructed by using an algebraic equation and are not easily made. The chart here illustrated is easily made and is clear and correct. It can be made in a few minutes, and with much more detail than shown in the sketch.



The chart is made by using coordinates. The ore in this case has a specific gravity of 2.65. On OY, lay off OB, which represents a specific gravity of 1 and which will be the specific gravity when the agitator, or whatever the receptacle containing the pulp, is full of water. Using the same scale, lay off OA on OX, representing the specific gravity of the receptacle when full of solids or ore. This quantity is 2.65. Now the line, AB, represents all specific gravities ranging from 1 to 2.65. Any intermediate specific gravity lines such as those shown on the chart may be found by dividing this line AB into 16.5 equal parts. (The difference between 2.65 and 1 is 1.65 and the line on the chart represents one-tenth of 1 per cent, therefore divide by 16.5 instead of 1.65 to get the divisions, such as BD on the chart). An equation containing two variable whose sum equals a constant is represented by a straight line 45 degrees to the ordinate. This is the case of the two variables, percentage of moisture and percentage of solids, the sum of which is always 100 per cent. Let this line be any such line as BC, and let the specific gravity lines cut BC. To read this chart, find the point where the line representing the specific gravity already determined cuts the line BC. Reading directly across from this point to the side scale will give the percentage of solids; directly down will give the percentage of moisture.

This chart can be changed to one for a pulp having an ore of different specific gravity than 2.65. In that case let OA on OX represent this new specific gravity in the same scale with OB.

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THE DORR COMPANY
ENGINEERS

NEW YORK
DENVER
SCRANTON

MEXICO CITY
LONDON, E. C.
HAVANA

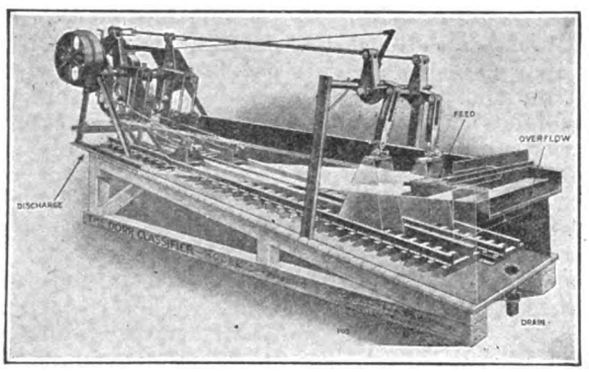
Methods and Equipment for the Continuous, Mechanical Washing, Settling, Classification or Agitation of Finely Divided Solids Suspended in Liquids

Experience and Organization

For years this company has been intimately associated with mining and metallurgical operations the world over. Dorr Equipment is the outgrowth of the fund of invaluable, first-hand information acquired by contact with the production and treatment of ores of every character in every mining field. And Dorr Engineers, in constant touch with most modern practice, are continually working for improvements in methods and equipment to effect still greater operating economies.

The Dorr Classifier

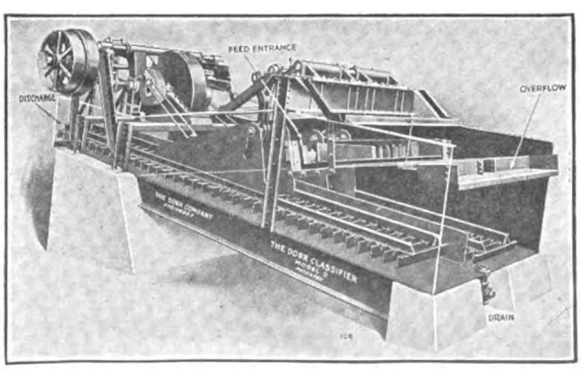
For the mechanical classifying or separating of ground ores or other products; making close separations at from 48 to 100 mesh, and regulating the



Dorr Classifier, Model "C"
(Patented)

fineness of the product from grinding mills in closed circuit grinding. It is used also for dewatering materials from ½-inch to 100 mesh, and discharging them containing 15% to 30% moisture in condition for handling by belt conveyor.

Model "C" Classifier is made in sizes from 15 inches by 10 feet to 4½ feet by 26 feet. Model "D" ranges from 6 to 8 feet in width and up to 26 feet in length. The capacity depends upon the size of the machine and upon the point at which separation is desired. Bulletin 11.



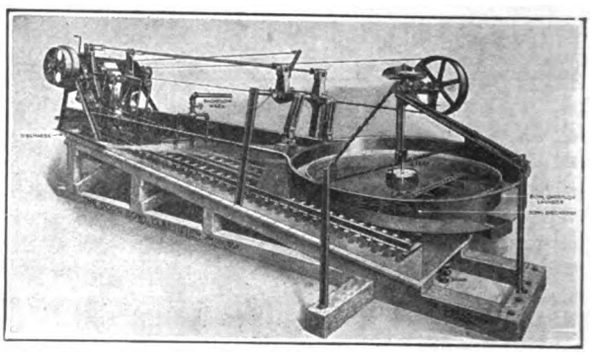
Dorr Classifier, Model "D"
(Patented)

The Dorr Bowl Classifier

For two-stage classification particularly adapted for separations at from 100 to 350 mesh, where an absolutely clean sand is wanted or where it is desired to secure a finished product all 300 mesh or finer. Suited also where a relatively large overflow of fine solids is sought, in comparison to the raking capacity required for the sands.

The Bowl Classifier, because of its closer separation, is especially valuable for very fine closed circuit classification. A bowl may be attached to any Model "C" or "D" Classifier, with an important improvement in its capacity for separations at fine mesh. This type of Classifier has made possible the much finer grinding of low grade ores, with a considerable increase in the capacity of the grinding mills and the production of a very clean, leachable sand.

In addition to giving cleaner products, the Bowl Classifier provides greater capacity per unit of floor space, and a lower capital and operating cost, than the standard Classifier of equivalent capacity. For dewatering large tonnages of granular material, such as mill tailings, it is unequaled. Bulletin 11.



Dorr Bowl Classifier
(Patented)

The Dorr Tray Thickener

This improved machine provides a larger thickening, or settling, capacity per unit of floor space than any other device for a similar purpose. Units of two, three and four compartments are in successful use. The large reduction in floor space means an important saving in initial equipment expense, building cost, power, up-keep and attendance.

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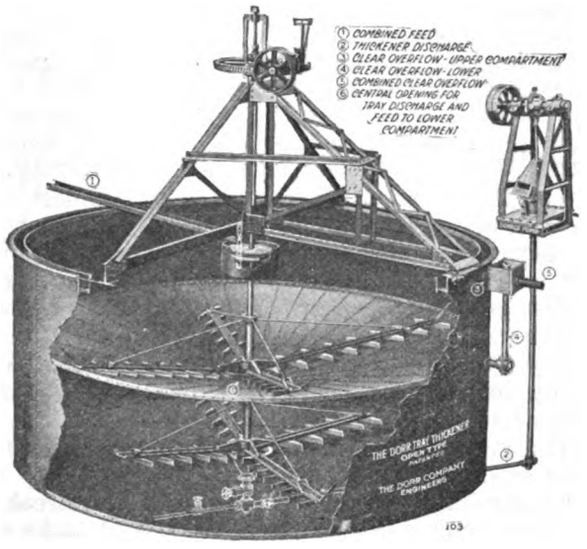
The Thickener is used in cyaniding, either with the Continuous Counter-Current Decantation System or for thickening ahead of filters. It has also found general adoption for dewatering ahead of tables or flotation cells, for collecting and dewatering concentrates, for recovering water from tailings, and in leaching copper, electrolytic zinc, copper cinder and cement copper.

Sizes up to 75 feet diameter. The capacity depends upon the physical nature of the material handled, but roughly from 5 to 25 square feet of tank area is needed per ton per 24 hours. Bulletin 12.



Dorr Tray Thickener
(Patented)

The Dorr Agitator

Has been generally adopted for agitating, mixing and equalizing pulp in many metallurgical and chemical processes, in which it has been found to produce uniform mixtures at lowest cost. It is possible to adjust the rapidity of agitation to suit the requirements of the material treated, thus giving perfect control at all times. Materials of 30 mesh and finer can be handled.

The Dorr Agitator can be operated either continuously or intermittently, but it is especially valuable in continuous operations, where an important saving both in plant and operating costs results. Continuous agitation has become the standard method in cyaniding, replacing the batch system prevalent a few years ago.

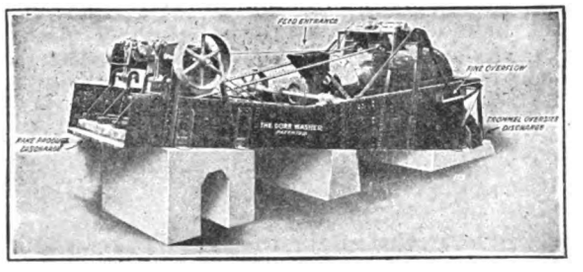
Dorr Agitator
(Patented)

Made in units up to 40 by 25 feet, with capacities determined by the nature of the material handled. The power requirements are very low and the up-keep costs insignificant. Bulletin 10.

The Dorr Washer

A combination of a Dorr Classifier with a trommel at the lower end of the classifier tank. It was developed for the washing of iron ore too low-grade to be shipped and can be supplied in a number of sizes to meet various conditions.

It is a complete, one-unit, self-contained washing plant, requiring the minimum of floor space and head room, and producing satisfactory results with a material saving in first cost, power, labor and upkeep. Bulletin 19.



Dorr Washer
(Patented)

Continuous Counter-Current Decantation

A system of washing finely divided solids free from the solutions in which they are suspended. It has come into general use in cyaniding in hundreds of plants, recovering over 99% of the gold and silver in solution at a cost varying from 3 to 6 cents per ton of ore treated.

The Dorr Thickener made possible the first commercially successful continuous counter-current decantation plant in the United States. Since that time Dorr Equipment has been used in important plants of this type the world over. The company's experience covers intimate contact with every development of this system and is at the service of all considering problems of this character. Bulletin 15.

Dorr Engineering

Dorr Engineering Service offers the combined experience of the Dorr Technical Staff to all who are interested in the betterment of processes and lowering of costs. It makes available an intimate knowledge of mining and metallurgical practice gained from contact with operations in every part of the world.

The Dorr laboratories are equipped for research, development and tests in pound or ton lots. The Company has a fund of information available to interested parties, gleaned in every field where processes involving its own or similar equipment are used.

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COLORADO IRON WORKS CO.

Main Office and Works, DENVER, COLORADO

Branch Office, 30 Church St., NEW YORK

Ore Milling Machinery and Smelting Equipment, Since 1860

Cyanide Plants

Located in the heart of the Rocky Mountain mining district we have made the most of our opportunity to follow the developments in ore treatment.

We have not only kept fully abreast of all the advancements in the Cyanide Process since it first came into use in America, but have been leaders in its progress and have ourselves contributed in large measure to its present high state of efficiency.

We design, equip, and erect complete cyanide plants, and have many to our credit. Our personnel includes metallurgists equipped with the knowledge and experience requisite for the determination of the details of treatment best suited to the conditions, engineers skilled in design, and thoroughly competent supervisors of erection. Only such a strong combination can assure the best results as to cost of the plant, time of erection, and efficiency in operation.

It will be to the interest of those considering the erection of cyanide plants to communicate with us.

The Akins Classifier

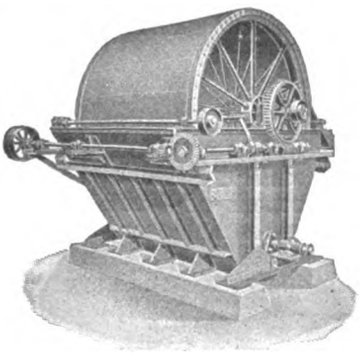
See description in the Mill Machinery section of this catalogue.

Queen City Castings

Of Manganese and Chrome Steel are proving equal to the best for the wearing parts of crushing and grinding machinery. Write us for prices.

The Portland Filter

The revolving drum filter has practically supplanted all others for the final washing of slimes in the cyanide process and for dewatering flotation concentrates, by reason of its automatic and continuous operation and low cost of labor, power, and up-keep.



The Portland Filter

The Portland Filter represents the highest development of the revolving drum filter, offering advantages over any other in facility of installation, substantial construction, and in a number of important details which contribute to secure better operating results. Hundreds of them are in continuous operation, in small as well as large plants; many at altitudes exceeding 10,000 feet, and all giving the highest degree of satisfaction.

Every filter is set up complete in our shops and all parts plainly marked for easy erection at destination.

In the Portland Filter a single series of pipes serves for both suction and pressure. This insures a very dry cake, as moisture would be blown back into the cake were separate pipes used. An economy of vacuum and compressed air is also effected, as there is but half the dead space in the piping.

The Portland patent valve is the simplest conceivable, and of extremely long life. Its construction permits precise adjustment of the operation of each panel during the various parts of its cycle of revolution. One, two, or three filtrates may be collected at will.

The Portland patent method of absolute panel sealing insures the maximum efficiency by sharp separation between suction and pressure.

The Portland patent wire winding, securely fastened at intervals, precludes the possibility of the entire winding becoming snarled should a break of the wire occur, and eliminates the use of tacks and staples which cause early failure of the fabric.

We build the Portland Filter in a large number of sizes so that all conditions can be met to the best of advantage. Our pamphlet 28-C, "Continuous Filtration with the Portland Filter" is very complete, giving much valuable information about this machine and about filtration in general.

Diaphragm Pumps

The Colorado Diaphragm Pump has a cross-head and guide, giving a truly vertical movement to the diaphragm.

It has an eccentric, adjustable as to stroke, providing ready means for nicely regulating the amount of pulp delivered.

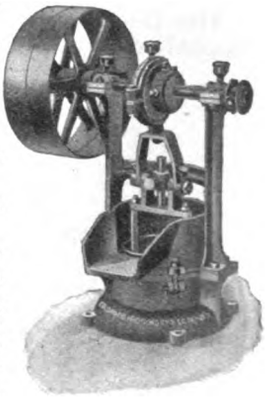
It has a novel means of attaching the diaphragm, whereby a worn-out one can be removed and a new one inserted without even taking off the belt.

The valves are easily accessible and renewable when necessary.

It is provided with tight and loose pulleys.

The bolts used for attaching the diaphragm are hinge bolts from which the nuts need not be removed, so that there is no chance of dropping nuts or bolts into a tank over which the pump may be placed.

It is built of different sizes, simple and duplex.



Diaphragm Pump

POWER DRIVEN DIAPHRAGM SUCTION PUMPS

Size No.	Cu. In. per Stroke	Size Pulleys	Speed R.P.M.	Weight Pounds	Power H.P.
3	195	18x3	80	300	½
4	285	24x4	30	500	¾

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THE FILTER FABRICS COMPANY

FELT BUILDING, SALT LAKE CITY, UTAH

FILTER CLOTH AND BAGS

Products

Filter Cloth in a Great Variety of Weaves.

Filter Bags, Filter Covers (Filter Sacks), for Every Type of Filter.

Flotation Porous Bottoms (sometimes termed Air Mats, Blankets, etc.) for Pneumatic Flotation Machines.

Wool Fume Bags, Ducks, Cordage, Twines.

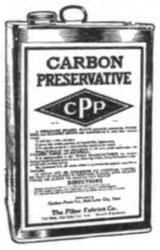
Canvas worked up into any desired form.

Carbon Preservative Coatings:

C.P.P. Roof Coating (Graphite) for Shingles, Iron and Composition.
C.P.P. Structural Iron (Graphite) Coating.
C.P.P. Cement and Concrete Coating.
C.P.P. Special Boiler and Stack Coating.
C.P.P. Ship Bottom Coating.
C.P.P. Black Diamond Coating, Acid and Alkali Proof.
(For Wire Fences, Machinery, Structural Iron, Elevators. Dries in two hours).

Carbon Preservative

Carbon Preservative can be used on any wood, metal or cement surface as a protection against any destructive agent—water, fire, acid, alkali, or insects. It is



Impervious to gases.

Prevents rust and decaying atmospheric influences.

Hydro-carbonizes all surfaces on which it is applied.

Greatly retards electrolysis.

Is not affected by heat, cold, sunshine, or moisture.

Acid, Alkali, Insect and Fireproof.

It will not peel off or crack, and is elastic.

It hardens to a glossy, varnish-like finish that makes an attractive surface.

"A Special Cloth for Every Filtration Purpose" Viz.:

Dewatering Flotation Concentrates.

Washing and Filtering Cyanide Slimes.

Chemical Filtration.

Oil Filtration.

Industrial Filtration.

Sugar Filtration.

Filter Bags or Covers for Every Type of Filter:

Filter bags made up for
Kelly Filters
Sweetland Filters
American Filters, Etc.

Filter covers made up to size ready for winding on drums for
Oliver Filters
Portland Filters, Etc.

Special Filter Bags made up to order.

Where bags are not necessary we furnish cloth cut to the size ready for instant use.

Write for Our Sample Book of Special Filter Fabrics

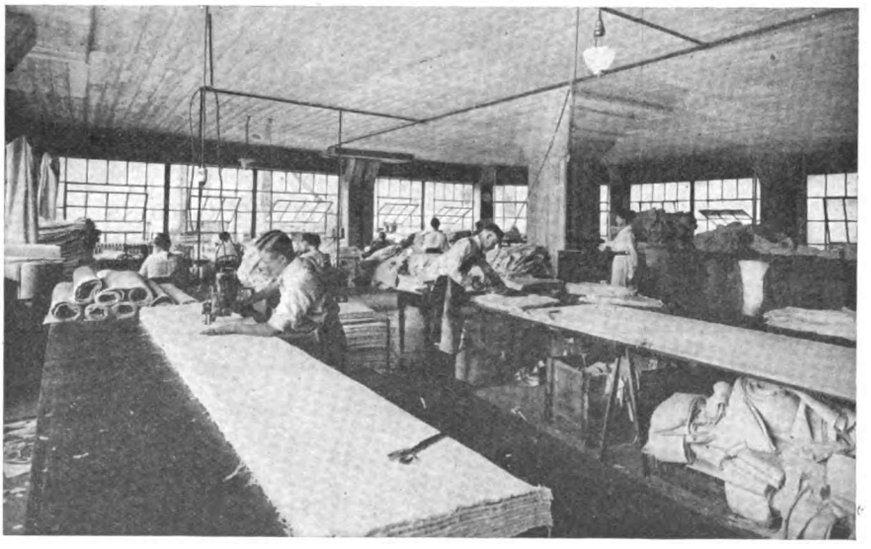
Miscellaneous

Cloths cut to size for Plate and Frame Filters. (Specify size or furnish template).

Canvas Bottoms, Cocoa Matting, Burlap furnished in any weight and shape.

Special Service

We are specialists in the field of filtration. We shall be pleased to suggest the best kind of cloth for your filtration problem.



Making Up Flotation Porous Bottoms. A Corner in the Factory of The Filter Fabrics Company

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EMIL E. LUNGWITZ

90 West Street, NEW YORK, N. Y.

Exclusive Licensee for Haubold Selfunloading, Rotary Pressure Filter in United States, Its Territories and Dependencies, Canada and Mexico

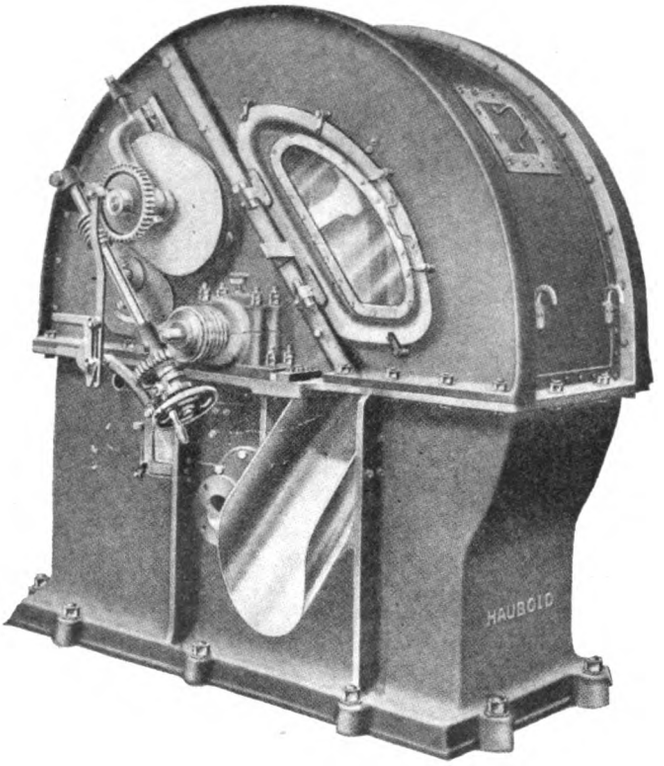
CHICAGO OFFICE—10 SO. LA SALLE STREET

Cable Address: Witzlung—New York
Codes Used: Bentley, Western Union 5 letter edition and A. B. C. 5th Edition

Haubold Selfunloading Rotary Pressure Filter

Construction

Simple, compact and self-contained.
Made of metal to suit all conditions.
Small floor space.
Small power required.
No Filter cloth.
Discharged product the dryest ever.
No complicated pipe or valve system.
No pressure or vacuum pumps or compressors are required.
Unrivalled washing effect.
Excellently adapted for "step" washing.
Little or no human labor.



SPECIFICATIONS

Size of Drum, Inches	Rev. per Minute	Safe Load, Lbs.	Drumring		Power Required		Size of Pulley, Inches	Charges per Hour	Capacity Cu. Ft. per Hour	Total Height, Inches	Floor Space Required, Inches	Weight, Lbs.
			Contents in Cu. Ft.	Thickness in Inches	To Start	Full Speed						
35x16	700	300	3	3.15	9	1.5	10x 4	10	30	53	52x 53	3500
48x16	600	550	4.5	4.75	12	2.5	16x 5.5	8	44	67	58x 71	5500
60x16	550	770	9	6	18	4	20x 6	6	54	78	75x 80	8500
79x20	500	1100	19	8	40	7	24x 8	5	100	98	82x106	14000
97x30	400	2700	45	10	80	10	32x10	4	180	122	124x124	30000

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UNITED FILTERS CORPORATION

HAZLETON, PA.

Branches in New York, Chicago, Salt Lake City, Los Angeles

Cable Address
"UNIFILTER" New York

Codes Used
Bentleys; Western Union 5-Letter

Manufacturers of Industrial Filters and Filter Presses

Products

American Continuous Filter.
Sweetland and Kelly Pressure Filters.
United Filter Press.
Metallic Filter Cloth, Cotton Filter Cloth.

The American Continuous Filter

Vacuum Type.
Automatic and Continuous Operation.
Disc Design.
Special Construction for Acid Problems.
Cake Washing Mechanism.
Belt or Individual Motor Drive.

Metal Mining Applications

Dewatering cyanide slimes, oil flotation, copper, zinc, lead and silver concentrates. Particularly adapted to electrometallurgical work.

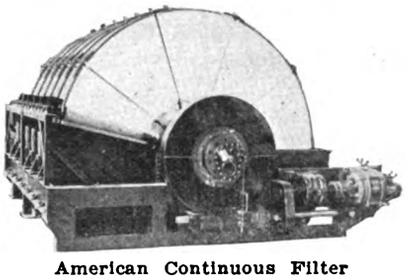
American Filter Features

The disc arrangement of the filtering elements gives much greater filter area and capacity per unit of floor space than any other type of continuous filter, and the subdivision of the discs into small filtering units or sectors permits an entire or partial change of cloth to be quickly made. Large vacuum passage ways and a thorough cleaning of cloth every rotation of discs insure a high rate of filtration. Ample drainage of sectors assures driest possible cake.

TABLE OF AMERICAN CONTINUOUS FILTER SIZES

Diam. of Disc	No. of Discs	Area Sq. Ft.	Diam. of Disc	No. of Discs	Area Sq. Ft.
4′	1	22	6′	5	250
4′	2	44	6′	6	300
4′	3	66	8′	2	200
4′	4	88	8′	3	300
6′	2	100	8′	4	400
6′	3	150	8′	5	500
6′	4	200	8′	6	600

American Filter Disc and Shaft Section



American Continuous Filter

The Sweetland Filter

Pressure Type.
Automatic Discharge.
Leaf Filtering Elements.
Sight Glass Filtrate Outlets.
Cast Iron Body Construction.
Special Construction for Acid Problems.

Metal Mining Application

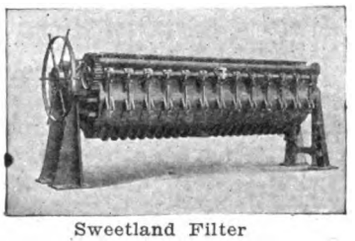
Clarification of leaching or other metallurgical solutions containing small percentage of suspended solids. Recovery of finely divided metallic copper, etc., from waste waters resulting from leaching operations. Clarification of electrolyte solutions.

Sweetland Filter Features

The Sweetland Filter has only one body joint and this is perfectly tight under operating conditions, thereby eliminating the sloppy filter station. A quick locking device enables the filter to be opened or closed readily. Filter leaves are interchangeable, easily handled and can be quickly recovered with cloth. An internal sluicing arrangement makes it possible to remove solids which adhere closely to the filter cloth and also to discharge cake without opening filter where a wet discharge is permissible. Filtrate from each leaf passes through a sight glass. Design is adapted to the use of metallic filter cloth.

TABLE OF SWEETLAND FILTER SIZES

Filter No.	Diam. Inches	Length Inches	Filter Area Square Feet		
			2″ Leaf Centers	3″ Leaf Centers	4″ Leaf Centers
2	16	36.5	46	31	24
5	25	61	190	131	98
7	25	82	268	177	131
10	31	109	536	364	273
12	37	145	1030	695	522



Sweetland Filter

United Filter Press

The United Filter Press

Plate and Frame, and Recessed Plate Types.
Corner, Center and Side Feeds.
Open or Closed Delivery.
Single, Double and Non-Washing Types.
Iron or Wooden Construction.

United Filter Press Features

The advantages of United Filter Presses rest upon good design, and substantial and accurate construction. Plates and frames are made of ample strength with liberal joint surfaces and large inlet and outlet ports. The plates for iron presses have reinforced pyramid drainage surfaces combining strength with maximum drainage efficiency. Filter cloth is supported so as to reduce wear.

Wooden presses are made from carefully selected and seasoned material.

TABLE OF UNITED FILTER PRESS SIZES

Size	No. of Chambers	Area Sq. Ft.	Size	No. of Chambers	Area Sq. Ft.
18″ x 18″	12	47	30″ x 30″	24	267
	18	70		30	333
	24	94		36	400
	30	117		48	534
24″ x ″24	24	170	36″ x 36″	36	586
	30	212		42	683
	36	255		48	781
	42	297		60	976

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UNITED LEAD COMPANY

111 Broadway, NEW YORK, N. Y.

"United" Lined Products

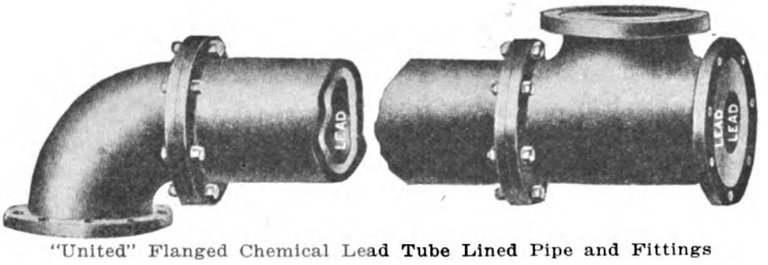
"United" Lined Products

Chemical Lead Tube Lined Steel Pipe; Chemical Lead Lined Cast Iron Fittings; Chemical Lead Lined Cast Iron Valves; Chemical Lead Lined and Covered Bore Hole Stubs; Chemical Lead Lined and Covered Suction Pipes; Chemical Lead Lined Foot Elbows; Chemical Lead Lined Wood to Iron Pipe Fittings; Chemical Hard Lead Foot Valves and Strainers; Chemical Lead Lined Check Valves; Chemical Hard Lead Centrifugal Acid Pumps; Chemical Hard Lead Plug Bibbs and Cocks.

Also all kinds of Chemical Lead Covered, Coated and Lined Sheets, Bars, Tubes, Special Apparatus.

Advantages of "United" Products

A large percentage of the ores of the valuable metals which are mined, especially those of copper, lead and zinc, contain these metals and other less valuable metals, such as iron, in the form of sulphides. Under certain conditions these sulphides readily oxidize, forming sulphuric acid and various chemical salts. The sulphuric acid and salts, when dissolved in the mine water, make solutions which are highly corrosive to iron and steel materials. This necessitates the use of non-corrosive installations.



"United" Flanged Chemical Lead Tube Lined Pipe and Fittings

There are also a number of processes used in this field which involve the handling of extremely corrosive solutions, etc., which conditions call for acid resisting equipment.

For this work "United" products offer the following advantages:

Protection against acid mine waters and corrosive solutions.

Ease and rapidity of installation.

Strength and durability.

Low cost of maintenance.

"United" Chemical Lead Tube Lined Pipe

"United" Chemical Lead Tube Lined Wrought Steel Pipe is lined with a seamless chemical lead tube inseparably bonded to the steel. This is the only method which gives a uniform lead lining free from pin, blow holes, etc.

"United" Chemical Lead Tube Lined Flanged Pipe and Fittings

"United" Chemical Lead Tube Lined Flanged Steel Pipe and Fittings are particularly adapted for use in contact with acidulous waters and acids. Flanged material is always advisable for such conditions, as it is practically impossible to secure tight connections with the use of screwed material owing to the searching nature of acids.

In making up flanged pipe the bonded lead lining is turned over the face of the recessed flange which gives a perfect lead to lead joint.

All "United" flanged pipe and flanged fittings are standard, faced and drilled to A.S.M.E. standard, unless otherwise specified. Flanged Lead Lined Pipe is cut and made up to sketch or blue print.

"United" Chemical Hard Lead Lined Acid Valves

"United" Chemical Hard Lead Lined Valves are heavily lined throughout with Chemical Hard LEAD and being constructed of iron, except the lining, offer the acid resisting qualities of chemical lead, with the strength of the cast iron valve.

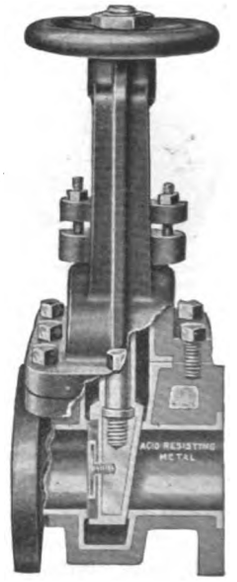
"United" Chemical Hard Lead Lined "Y" Pattern Plug and Seat Type Acid Valve

The flanges, to offer additional strength, are made extra strong.

These valves are made in all required sizes and styles; Globe, Gate, Angle, "Y" Pattern or Free Flow Type.

Your particular attention is called to the new "United" Wedge Type Gate Valve, which is the most efficient of any acid gate valve and is positively tight when closed.

"United" Acid Valves can be furnished where required, with soft or hard rubber disc.



United Chemical Hard Lead Lined Wedge Type Gate Pattern Acid Valve

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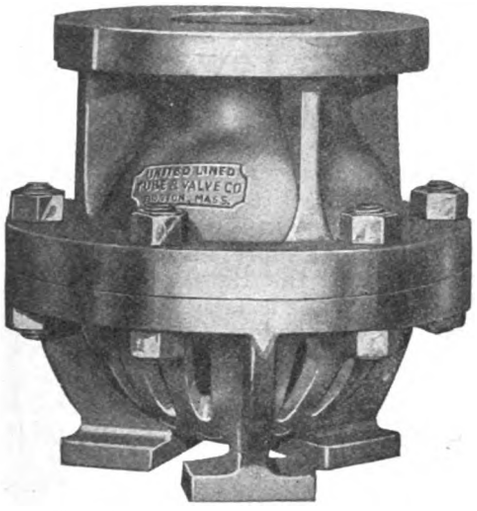
"United" Chemical Hard Lead Foot Valves

"United" Chemical Hard Lead Foot Valves, as illustrated below, are made of cast Chemical Hard



"United" Acid-Proof Metal Foot Valve

Lead. These valves are heavily built throughout and are of simple and durable design.

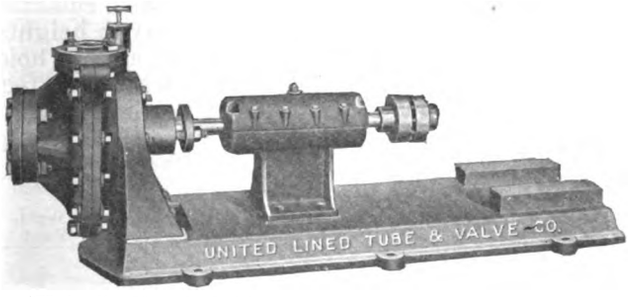
"United" Chemical Hard Lead Lined Check Valves

We also manufacture, in all sizes, "United" Chemical Hard Lead Lined Flanged Check Valves. These are constructed of cast iron, and therefore offer the strength of the cast iron valve and are lined throughout with the best grade of chemical hard lead, which gives them their acid resisting qualities.

"United" Chemical Hard Lead Centrifugal Acid Pumps

"United" Acid Pumps are made of Chemical Hard Lead, with heavy reinforcing ribs cast on the shell or casing.

All parts coming in contact with acid or other corrosive chemicals are thoroughly protected.



"United" Chemical Hard Lead Centrifugal Acid Pump Furnished for Belt or Direct Drive

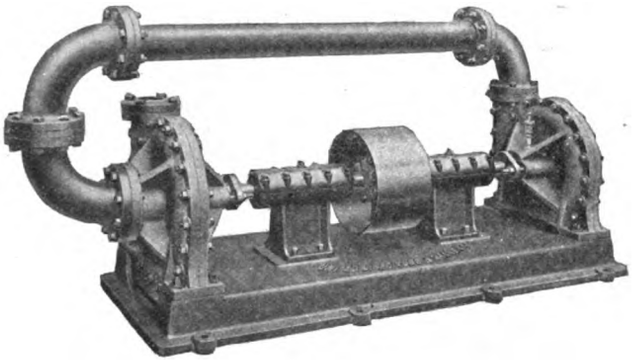
"United" Acid Pumps are extra strong for heavy service and durability. They, in addition, possess the following essental features:

Self-lubricating, with large internal grease gland supplied by acid-proof compression grease cup. Outside bearings are self-oiling and the front pillow block is equipped with self-aligning thrust bearings with thrusts running in oil and properly housed.

They are equipped with our specially constructed Leak-Proof Stuffing Box and Packing.

"United" Twin Chemical Hard Lead Centrifugal Acid Pump

"United" Pumps are also made in twin or multi-stage patterns, for operating against greater heads than the single pump can successfully negotiate.



"United" Hard Lead Centrifugal Twin Acid Pump Furnished for Belt or Direct Drive

"United" Chemical Lead Covered Products

In addition to the foregoing we are in a position to furnish a complete line of chemical lead covered sheets, tubes and bars of steel, copper or brass, suitable for various uses in the construction of copper, zinc leaching and refining plants. This covering is put on in the same way as the linings and gives the same satisfactory service.

For such cases where a high grade covering is not necessary, as when subjected to fumes only, we can furnish lead coated material. This coating is approximately .0025 of an inch in thickness and must not be confused with our covering. It does, however, protect overhead construction from corrosive fumes, etc.

Co-Operative Service

Our Engineering Department is prepared to offer its services to any mining company having acid water problems to solve.

If blue prints or sketches are submitted to us, we will be pleased to offer suggestions in detail as to the most economical and satisfactory use of "United" Lined Products.

Prices and samples will be sent to interested parties upon request.

ALL "UNITED" LINED PRODUCTS ARE ABSOLUTELY GUARANTEED.

A copy of Our Catalog should be in your possession. Write for it.

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W. E. CALDWELL CO.

INCORPORATED

2360 Brook Street, LOUISVILLE, KY.

Manufacturers of Tanks and Tank Towers

Products

Wood, steel and galvanized tanks, any shape or size, for any purpose; tubular, angle or channel column steel and wood towers; railroad tank fixtures; tank agitators; friction clutches and pulleys; gearing and general power transmission machinery.

THE TANK WITH A REPUTATION
Caldwell
TANKS AND TOWERS

Wooden Tanks

For thirty-five years we have been making high-grade wooden tanks for water and other purposes. We have always specialized in Cypress and we have found it to be the most durable wood for tank purposes in all parts of the world. In addition to its durability it possesses a minimum of shrinkage and swelling and gives no taste or coloring to the contents of the tank. Recently we have been using Fir, as we have found that it possesses a great many of the qualities of Cypress and costs considerably less. We also use Yellow and White Pine and White Cedar to a limited extent. Wooden tanks can be made in any size and shape and for any purpose. The careful selection of materials, design and workmanship are the reasons for Caldwell tanks being known the world over as "The Tank With a Reputation."

Specifications

Lumber to be thoroughly dry, without loose or unsound knots, splits, shakes, pecks, wormholes or other defects all heart on inside; sound sap on outside, and then not to exceed one-half of the thickness of stave.

THICKNESS—2 inch for 10,000 gallons or less; 2½ inches up to 20,000 gallons; 3 inches for larger sizes. Finished thicknesses to be ¼ inch less than above.

STANDARD INSIDE DIAMETERS—ROUND TANKS—Are every 6 inches from 3 to 9 feet; every foot to 16 feet; and every 2 feet above 16 feet.

STANDARD INSIDE DEPTHS OF ROUND TANKS—Are 1 ft. 5 in.; 2 ft.; 2 ft. 5 in.; 3 ft.; 3 ft. 5 in.; 4 ft.; 4 ft. 5 in.; 5 ft.; 5 ft. 5 in.; 6 ft.; 6 ft. 5 in.; 7 ft. 5 in.; 9 ft. 5 in.; 11 ft. 5 in.; 13 ft. 5 in.; 15 ft. 4 in.; 17 ft. 4 in.; 19 ft. 4 in.; 21 ft. 4 in.; and 23 ft. 4 in.

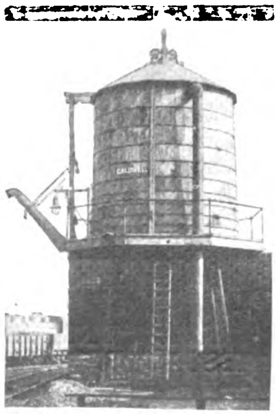
FINISH—Staves to be dressed both sides with edges machine jointed to proper bevel. Bottom dressed on top side only with edges machine jointed and square and well doweled.

HOOPS—Round hoops of wrought iron (not steel) with malleable iron draw lugs; sizes and spacing to give a factor of safety of 4 to 1 or greater if required.

INSIDE DIMENSIONS OF RECTANGULAR TANKS—There are so many possible sizes of these tanks that we do not attempt to list them. Standard lengths of lumber are in even feet and for economy inside length dimensions should be about 1 foot less or in odd feet. The width and depth, of course, can be varied to suit.

INTERIORS—Tanks can be fitted with partitions, false bottoms, etc., and lined with lead, copper or such other lining as may be required. Rods can be furnished in brass, copper, bronze, galvanized, lead covered or Durion as required. Agitators for either hand or power can also be furnished.

Our Research Department will be glad to go into any special problem with you.



Steel Tanks

Caldwell Tanks were originally made only of wood but later on the manufacture of steel tanks was taken up. These steel tanks, in the larger sizes, are being more and more extensively used and the Hemispherical bottom tank is as inexpensive in first cost as the wooden tank. Thin galvanized tanks are recommended only in the smaller sizes and for intermittent or temporary use. Heavy steel tanks can be furnished in any size or shape.

SPECIFICATIONS—Standard diameters and depths are in even feet while thicknesses are ⅛-inch for 10 ft. and less; 3/16 up to 16 ft.; ¼-inch up to 24 ft.; and 5/16-inch above 24 ft.

Steel tanks can be furnished set up, in the smaller sizes; or knocked down, punched, fitted and bent to shape, with the necessary rivets in the larger sizes.

Tank Foundations

Realizing to what an extent the success of a tank depends on its foundation, we have made a careful study of tank foundations and have developed a series of standard designs which are not only of the proper strength but also use the minimum of material.

Tank Towers

In a great many cases it is necessary to use a tower to secure sufficient pressure, and for this purpose we build three types of towers, each having its own advantages.

Tubular Towers are built of tubular steel columns and struts in all sizes from 15 to 100 feet in 12-foot sections; and to hold tanks of 100,000 gallons and less.

Angle Towers are built of heavy angle columns and struts in all sizes from 12 to 102 ft. in 10-ft. sections; and to hold tanks of 25,000 gallons and less.

Latticed Towers are built of laced steel columns and channel struts (bridge construction) in heights of 20 feet and up in 5-foot intervals; and to hold wooden tanks of 100,000 gallons and less; and steel tanks of any capacity with either flat or hemispherical bottoms.

Dimensions and Capacities of Standard Tower Tanks

Capacity Gals.	Wooden Tanks Diameter Ft.	In.	Depth Ft.	In.	Steel or Galvanized Tanks Diameter Feet	Depth Feet
1,000	6	6	4	5	6	5
1,500	6	6	6	5	6	6
2,800	8	0	7	5	8	7
3,000	8	0	8	5	8	8
5,000	10	0	9	5	10	8
6,000	10	0	11	5	10	10
10,000	12	6	11	5	12	12
12,000	12	6	13	5	12	14
15,000	14	0	13	5	14	14
17,000	14	0	15	5	14	16
20,000	16	0	13	5	16	14
22,000	16	0	15	5	16	16
25,000	16	0	17	4	16	18
30,000	18	0	15	4	18	16
33,000	18	0	17	4	18	18
35,000	18	0	19	4	18	20
36,000	19	6	17	4	20	16
40,000	19	6	19	4	20	18
50,000	22	0	17	4	22	18
55,000	22	0	19	4	22	20

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NATIONAL TANK & PIPE COMPANY

165 Columbia Boulevard, PORTLAND, OREGON

WOOD PRODUCTS

Tanks, Reduction Plants, Cross Arms, Silos, Specialties

Products

TANKS, including Mining Tanks, Acid Tanks, Pulp Tanks, Conical Bottom Tanks, Thickener Tanks, Agitating Tanks, Zinc Boxes, Flotation Tanks, Acid Towers, Car Tanks, Water Tanks, Oil Tanks, Railroad Tanks, Rectangular Tanks.

Cyanide Plants—Leaching and Agitating Plants Complete

ACCESSORIES (Cyanide Plant) such as Discharge Doors, Zinc Lathes, Distributors, Classifiers, Cast Iron Drying Pans, Pipe, Fittings, etc.

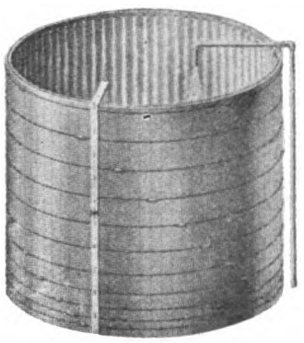
CROSS ARMS for carrying over-head wires such as Telephone, Telegraph, Power Lines, etc.

SILOS for curing and storing silage.

WOOD TANKS. Douglas Fir or California Redwood thoroughly seasoned. Diameters 1 ft. to 100 ft.; height 1 ft. to 50 ft.; thickness of material up to 6 in. Hooping standard round rolled mild steel bands. Special hooping either flat or round steel, as desired.

Headed Pressure Tanks

Equipped with steel or wood buck stays. Oil Tanks either plain or with patent non-shrinking devices. Other tanks plain or patent, as desired.



Patented Water Tank

Delivery

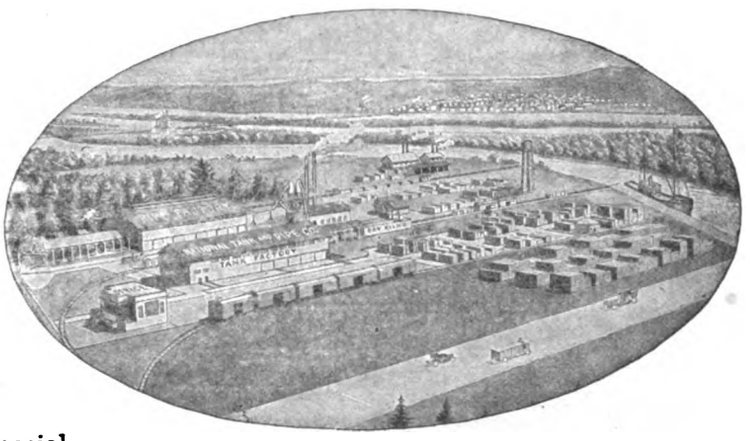
Large and varied stock on hand assures prompt delivery of any order.

Shipping Facilities

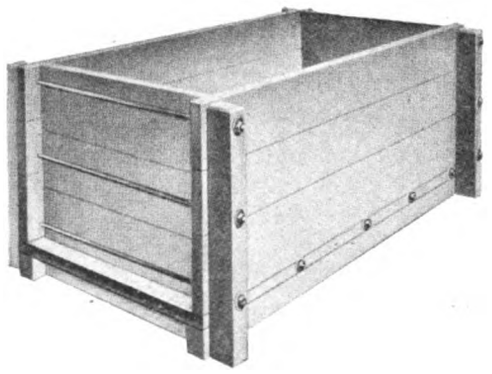
Five Transcontinental Railroads. Water transportation to any port.

Manufacturing Facilities

Our factory, covering 12 acres at Portland, Ore., is one of the largest factories in the United States specializing in Tanks, Silos and Cross Arms. Our Engineering Department is thoroughly competent to solve any tank problems submitted.



View of Factory



Rectangular Tanks of All Sizes for Any Purpose

Mill Department

Specializing in kiln dried finish, flooring, pump rods, ceiling, special timbers, etc. Dimension or finish run to special patterns.

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THE PACIFIC LUMBER COMPANY

Main Office
311 California St., SAN FRANCISCO, CAL.

Mills at
Scotia, Humboldt County, California

Branch Office
Central Bldg., 6th & Main Sts., Los Angeles, Cal.

THE PACIFIC LUMBER COMPANY OF ILLINOIS
Mid-Western and Eastern Distributors
Main Office, 2098 McCormick Bldg., Chicago, Ill.

Branch Office, 40 Rector St. Bldg., New York City, N. Y.

EXPORT COMPANY—A. F. THANE & CO.
San Francisco, Cal.—311 California St. New York City, N. Y.—40 Rector St. Bldg.

Manufacturers of Redwood Lumber for Tanks

Product

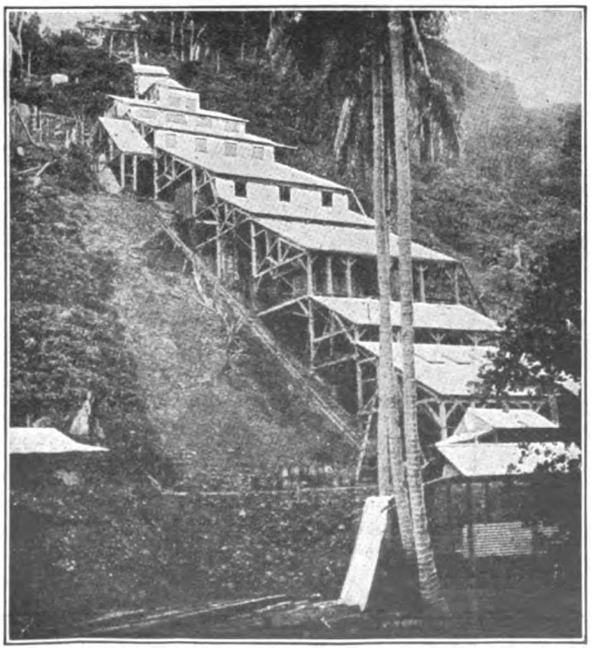
California Redwood—a non-resinous, soft wood, permeated during growth with an odorless natural preservative. An ideal material for tank staves and bottoms. Resists acid action, rot and fire.

Metal Mining Uses For Redwood

Solution Tanks	Acid Tanks
Leaching Tanks	Settling Tanks
Sump Tanks	Vacuum Clean-Up Tanks
Gold Storage Tanks	Water Tanks
Wood Precipitation Boxes	Oil Tanks
Agitating Tanks	Flotation Cells

Qualities of Redwood For Tanks

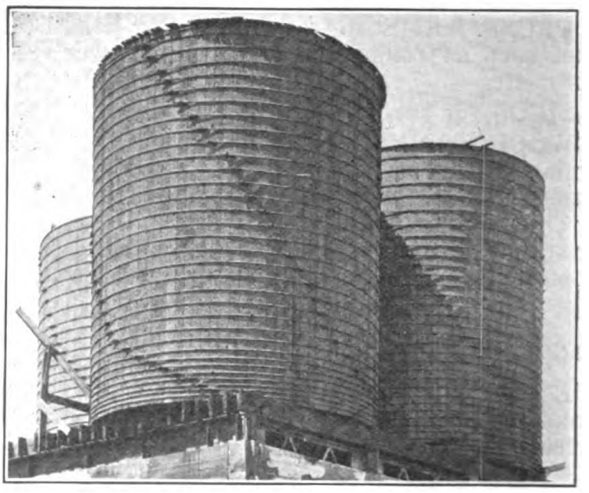
Long experience has proved to thousands of satisfied users, that California Redwood (Sequoia Sempervirens) is the best obtainable material for tanks. The trees from which the lumber is cut range in age from 500 to 2000 years. These Redwood forests belong to an entirely different geological period from the growth upon any other portion of the continent. There is no similar wood found in any part of the world.



Redwood Tanks Resist Adverse Climate Conditions
Colorado Mining Company, Philippine Islands

Redwood contains a natural preservative which makes it impervious to the destructive action of acids and alkalis. It resists decay so well that trees which have lain five hundred years in the forests have been sent to the mill and sawed into lumber. For engineering purposes in contact with ground or moisture, Redwood can be depended upon to maintain its full strength and service from 15 years upward.

Seasoned Redwood is one of the strongest woods for its weight. It is soft and yet strong enough to resist the most severe stresses. Its breaking strength according to the U. S. Government figures is 62 per cent. that of White Oak, which is probably the strongest and toughest of American woods. Redwood actually grows stronger with age.



Redwood Tanks After Withstanding Severe Fires

These remarkable trees contain no pitch nor resinous matter and the wood is very difficult to ignite and very slow burning even when dry. Here is what a noted Fire Chief after more than 22 years in the San Francisco Fire Department says: "Under similar conditions of heat exposure Redwood lumber ignites much less quickly and burns much slower than resinous soft building wood, and I am also convinced that when Redwood becomes ignited the fire is much more easily extinguished than other soft building woods."

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When properly seasoned Redwood shrinks less than any other wood, is not affected by changes in temperature and does not warp.

The grain in Redwood is straight and it may be procured in large pieces absolutely free from knots, splits or other imperfections.

Redwood is particularly adapted to all kinds of tanks, and is used for water tanks, cyanide plants, and acid tanks. Following are eight good reasons for using Redwood Tanks:

1. They are preserved by water and not rusted or corroded by it.

2. They are not corroded by sulphur or mineral water and fumes.

3. They are not destroyed by reasonably strong solutions of acids or salts.

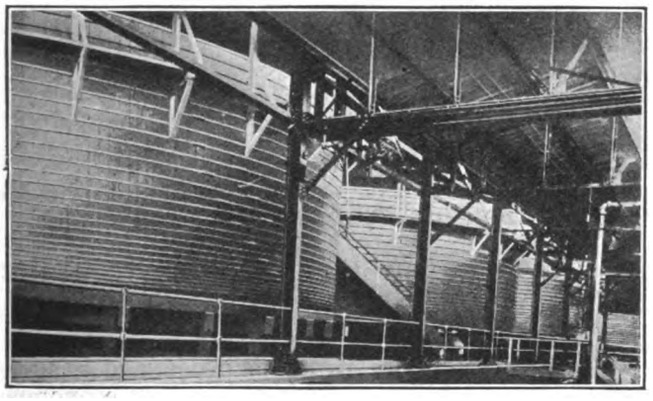
4. It requires less labor and expense to erect them than metal tanks.

5. They are cheaper than steel or galvanized iron tanks.

6. Their durability exceeds either steel or galvanized iron.

7. They keep water cooler in summer and warmer in winter.

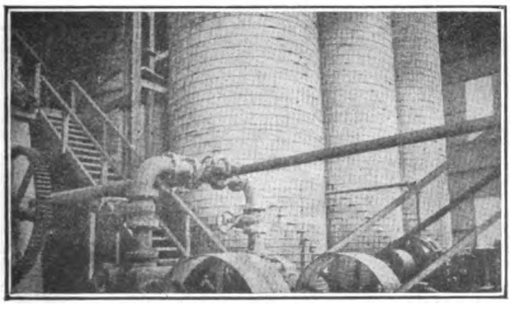
8. They are easily taken down and reassembled at another point, which is not practical in the case of metal tanks.



50 x 12 Ft. Copper Leaching Tanks of Redwood In the Anaconda Copper Mining Company's Plant, Anaconda, Mont.

Redwood Tanks

Redwood makes a superior stave for tanks.



Nine Wood-Stave Pachuca Agitation Tanks, 15 ft. Diameter by 45 ft. High, Installed in Large Cyanide Plant in Nevada

Redwood is a non-conductor of heat and cold; 2 in. of Redwood is equivalent in insulating power to approximately 30 in. of steel or concrete. This is an element of high importance in the stave for this use because it preserves the temperature of the contents of the tank.

Redwood staves are made from clear heart straight-grain stock, and come in standard sets of 6 to 9 ft. and 10 to 20 ft. in length.

Redwood's long life and its resistance to decay or corrosive acids and alkalis make it extremely valuable for tanks. Redwood tanks can handle muriatic acid solutions up to 6%, and up to 28% of nitrohydrochloric acid.

Redwood tanks are used at metal mines, where strong solutions of destructive acids are necessary in refining processes, or where the tank is called upon not only to stand up under years of service, but remain unaffected by the contents.

Redwood tanks will resist fire, are not injured or affected by arid climates or extremes of temperature. Redwood wears evenly under all sorts of service.

What Mining Companies Say About Redwood Tanks

Homestake Mining Co., Lead, South Dakota
We have 16 Redwood Tanks 44 feet in diameter by 9 feet deep, which have been in continuous service with alkaline solution for 15 years and they are in first class condition. We regard them as the best and will continue to put in Redwood for all new construction of this character.

Mineral Products Corp., Marysvale, Utah
Replying to your inquiry regarding the service given by Redwood tanks wish to advise you that we have a great number of these tanks in operation at our plant and they give most excellent service. In fact we consider them to be without exception the very best tank material. They are of especial value in handling solutions of an acid nature.

Tonopah Extension Mining Co., Tonopah, Nevada
We have a number of Redwood tanks installed here and they have given perfect satisfaction.

Arizona Copper Co., Ltd., Clifton, Arizona
The several Redwood tanks have given us entire satisfaction.

Nevada Hills Mining Co., Fairview, Nevada
The tanks have been in constant use since installation, April 17th, 1911, and have at all times given greatest satisfaction.

Engels Copper Mining Co., Keddie, California
We have considerable experience with the use of Redwood, both in Tanks and in Pipe, and in both cases same has proved far more successful than any other kind of wood. There seems to be absolutely no decay to the wood and they give evidence of lasting a life-time.

Winnemucca Mountain Mining Co., Winnemucca, Nevada
We are using Redwood tanks both for acid and saline solutions with the very best results.

Nevada Douglas Cons. Copper Co., Ludwig, Nevada
We can truly say that REDWOOD is far superior to any other wood for tank use.

Colorado Mining Co., Manila, P. I.
All the wooden tanks installed in our Cyanide Plant located in the Philippine Islands have proved themselves satisfactory in every way.

Jewel Denero Mines Co., Ltd., Greenwood, B. C., Canada
We take great pleasure in stating that every tank has given entire satisfaction. We have used a number of tanks in New Zealand and found that they gave the same results. They are ideal for cyanide mill work.

Giant Powder Co., Giant, California
During the year 1915 we had erected 4-100,000 gallon Redwood tanks here at Giant, California. They have been thoroughly satisfactory and we have no reason to regret placing our order.

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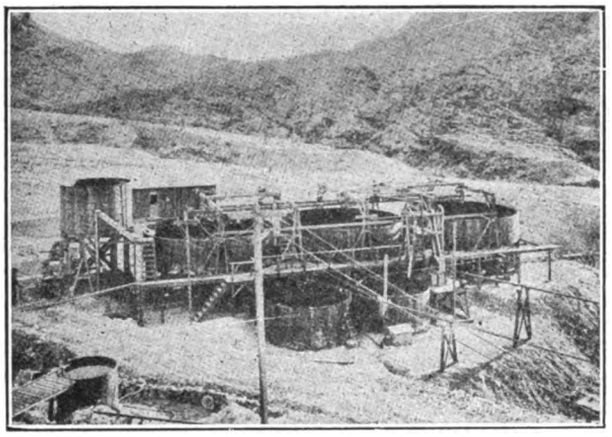
Mills, Facilities and Capacity

The Pacific Lumber Company is the largest manufacturer and distributor of Redwood lumber. Our annual production capacity is now over 125,000,000 ft. of Redwood.



Redwood Tanks on the Desert. 75-Ton Cyanide Plant of the Assets Realizing Mines Corp. at Blythe Junction, Cal.

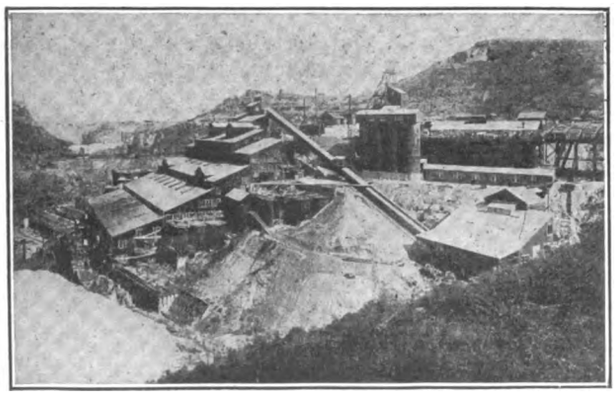
Owning many thousands of acres of the finest Redwood timber lands in Humboldt County, Cal., together with two large saw mills and planing mills located in Scotia, California, The Pacific Lumber Company further enhances its production facilities by owning all the commercial, housing and recreational buildings in the town of Scotia, in which the employees live.

It has exclusive use of the Leaver drying kilns, invented and constructed by an officer of the company to assist nature in drying Redwood for industrial use, at the same time not disturbing the the natural preservative that permeates Redwood.

Stocks and Shipments

Sawed and seasoned Redwood lumber of all sizes is continually carried in stock at the mills at Scotia —usually this stock approximates 75,000,000 ft. Production and shipping are facilitated by an electric overhead monorail system, which operates throughout the mills, yards and shipping houses.

Direct rail shipments to the Middle West and East are now made via the Northwestern Pacific Railroad, whose tracks adjoin the mills.

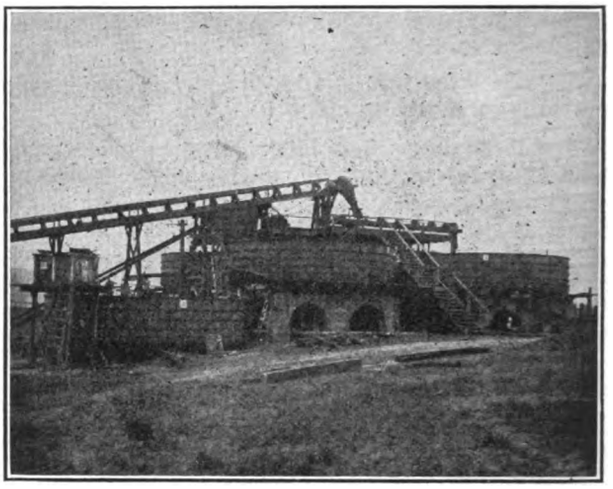


Eureka Hill Mining Company, Yankee, Utah. Redwood Tanks in Foreground

A large stock of Redwood is also carried at our "quick shipment" depot, in Chicago, to supply middle west and eastern demands where time is a factor. Shipments can be made from Chicago, either in carload or less than carload lots.

Sales Offices

Sales in the territory west of the Rocky Mountains are made from The Pacific Lumber Company's San Francisco office, 311 California street. A branch sales office is located in the Central Building, 6th and Main streets, Los Angeles.



Works of the Mountain Copper Co., Martinez, Cal., Showing five 26' x 6'4" Redwood Stave Tanks

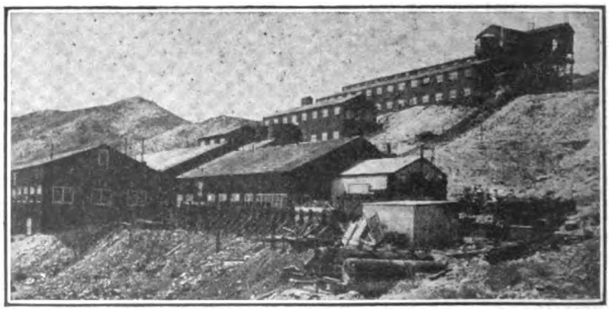
All sales in the territory east of the Rockies are made by The Pacific Lumber Company of Illinois.

Its general offices are in Chicago, in the McCormick Building, 332 South Michigan avenue.

The Atlantic Coast territory is handled through the New York Office, in the 40 Rector St. Bldg.

All of our offices are prepared to consult with any lumber user concerning his needs, and to advise as to the suitability of Redwood and its economical use.

If interested in the adaptability of Redwood for your requirements, we shall be glad to give full information and advice without obligation on your part.



Pittsburg Silver Peak Mill, Blair, Nevada, 26 x 24-foot Redwood Tanks Installed

NOTE—The photographs in these pages and page 527 are published through the courtesy of the Pacific Tank & Pipe Company.

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SECTION XIX

Smelting, Refining and Metallurgy

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Allis-Chalmers Mfg. Co.
American Abrasive Metals Co.
Bartlett, C. O. & Snow Co., The
Dwight & Lloyd Sintering Co., Inc.
General Chemical Co.
Ruggles-Coles Engineering Co.
Stearns-Roger Mfg. Co., The
Stroud, E. H. & Co.
Wiederholdt Construction Co.
Winslow Government Standard Scale Works, Inc.
Worthington Pump and Machinery Corporation.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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SOME ESSENTIALS FOR SUCCESS IN PYRITIC SMELTING*

The oxidizing charges which were formerly fed to copper blast furnaces are no longer common; changes in ore supply and advances in smelting practice have made the furnace an oxidizer instead of a reducer, and at times, under favorable conditions, a powerful one. Nearly all blast-furnace operators have to oxidize some iron, and many, with a thought for their converter departments, would like to do more of it.

The extent to which oxidation can be carried is influenced by many factors, chief of which are the relation of sulphide iron to the free silica on the charge, the nature of the gangue, and the amount of oxygen supplied by the blast. Best results, meaning high concentration and low coke, follow the use of pure materials such as heavy sulphide ore and quartz, or low-grade matte and quartz; but whether coarse Tennessee pyrrhotite and pure, lump quartz is smelted with 3 per cent of coke, oxidizing 90 per cent of the iron, or Sudbury pyrrhotite in a norite gangue is smelted with 10 per cent of coke, oxidizing only 35 per cent of the sulphide iron, the pyritic effect is equally desirable. In one operation the charge favors oxidation; in the other it is hampered by a refractory gangue and a high percentage of coke.

"Pyritic smelting," in a narrow sense, is associated with low coke ratios and implies a vigorous employment of the pyritic reaction. Guess defined it as "the art or practice of smelting a charge, in which all the iron present is combined with sulphur, to produce a ferrous-silicate slag."

The iron sulphides to be considered are pyrite and pyrrhotite. Pyrite loses one-half its sulphur by sublimation in the upper part of the smelting column, and both pyrite and pyrrhotite melt at a comparatively low temperature and enter the smelting zone approximately as FeS. The composition of the iron sulphide compound at its highest temperature is stated by Sticht to lie somewhere between FeS and Fe, FeS.

It is commonly held that the loose sulphur atom, for lack of free oxygen in the region of disengagement, escapes from the charge unburnt, and it is customary for this reason to deny to pyrite any credit for heat from this source. But such reasoning may not always hold; two circumstances challenge its soundness. First, some pyrite ores have the mineral scattered through the gangue in grains or patches, and, by means of the protection and insulation thus afforded during the early stages of the descent in the ore column, disengagement of the loose atom may be delayed until the smelting zone and an oxidizing atmosphere are reached. Second, the lack of free oxygen above the smelting zone is certainly open to question. It has been my experience that gas analyses from the pyrite charge show a high average oxygen efficiency, often no trace of oxygen being found, whereas, at a plant smelting an ore essentially pyrrhotite, an appreciable proportion of oxygen is invariably present, evidently because the pyrrhotite charge, unlike pyrite, lacks the abundance of liberated, elemental sulphur for cleansing the gas of oxygen unused in the smelting zone.

Pure Quartz the Best Form of Silica

The character of the siliceous portion of the charge is of much importance. The silica should be free; silicates require heat for decomposition and are a detriment in several ways. A coarse quartz that does not break down easily on exposure to heat is the ideal reagent; fine quartz, or one crumbling badly under heat, lowers the ratio of concentration and causes more incrustation. This has been clearly shown in the concentration of low-grade matte where pure materials were used, matte, quartz, and lime rock, and results were not obscured by many qualifying conditions, as in ore smelting. At one plant, using a good lump quartz, a 10 per cent matte was readily concentrated to 40 per cent; at another plant where the bulk of the quartz was fine, about ¾ in. or under, it was difficult to raise a 10 per cent matte beyond 25 per cent, and incrustation was bad. In pyritic smelting, prime attention should be given to silica—to its physical as well as to its chemical nature.

Fine and waste have no place in the blast-furnace charge, and this applies with special force in pyritic smelting. Fine material, say that passing a ½-in. opening, if there is no reverberatory department, may be prepared for the blast-furnace by nodulizing, sintering, or briquetting. Nodulizing and sintering have the advantage that oxidation accompanies the physical preparation, and as oxidation is the prime object of pyritic smelting, preparatory processes should preferably be a step in that direction A furnace, however, often does good work with all the fine left in the ore, and it may be difficult to show the need and justify the expense of screening and special treatment, as benefits to be derived from metallurgical operations are not always capable of exact expression in terms of money. If an ore with 20 per cent of fine is screened and prepared for the blast furnace at $1 per ton, the cost figured against total ore is 20c. per ton, a serious item for a low-grade ore; but on the opposite side of the ledger will be faster running, less crusting, longer campaigns, a decreased quantity of flue dust, and, if the preparatory process oxidizes, a higher grade of matte.

Waste rock, which is usually high in natural silicates, creates trouble and expense for the smelter. It is hard to estimate the cost of smelting waste. It entails the ordinary expense of transportation, bins, sampling, and charging, the same as ore; it increases the demand for coke, lime, or other flux; it is responsible for a certain amount of slag which carries a quantity of copper to the dump; but, what is far more serious and costly, is its deadening effect on the pyritic reaction. It retards the rate of smelting, depresses oxidation, and causes low-grade matte and sticky, dangerous slags. Waste in the ore should be eliminated outside of the blast furnace.

The pyritic furnace requires a careful balancing of reagents and maintenance of proper physical conditions. Frequent changes in the charge are necessary, and the metallurgist in diagnosing and pre-

*By A. J. Bone, formerly Smelter Superintendent at Copperhill, Tenn., and Anyox, B. C. Written for Engineering and Mining Journal.

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scribing should be able to feel confidence in the analyses and weights of charge components. Though the preponderance of tonnage may come from beds, provision must be made for a quick supply of any single material. An intimate bedded mixture is usually only necessary when conditions are particularly unfavorable.

Methods of Mechanical Feeding

Two improved methods of mechanical feeding, both successful though widely different in principle, have been developed in pyritic plants. The Freeland feeder, described in th Mining & Scientific Press of March 22, 1913, has been used since 1902 in the smelter of the Ducktown Sulphur, Copper & Iron Co., at Isabella, Tenn. The Isabella furnaces have gas offtakes beneath the charge floor, and movable, water-cooled tops or covers. The feeding machine operates on a charge track that straddles the furnace lengthwise. It consists of a carriage supporting an apron conveyor of the same length and width as the furnace. Charge components are drawn through wide gates onto the conveyor in layers, as ore, quartz, slag and coke. The carriage engages the cover of the furnace and pushes it ahead, and as it moves over the opened shaft the conveyor distributes its burden uniformly not only lengthwise but from side to side. The carriage and conveyor each has a variable-speed, reversible-type motor, giving flexibility to the method.

An adaptation of the system of feeding developed at Mount Lyell, Tasmania, is employed by the Granby smelter at Anyox, B. C. It was described in the Engineering and Mining Journal, Oct. 7, 1916. Extending along either side of a 30-ft. furnace, at a point 2 ft. 6 in. below the charge floor, is an iron ledge or shelf projecting into the furnace and overhanging the jackets 9 in. This ledge, which receives the charge from side-dump cars, is partitioned into six compartments, and each compartment is served by a pusher, actuated by compressed air, for moving the charge into the furnace. Thus, a furnace has twelve feeding units, and can be fed from any one, at any time, and in any quantity up to capacity, which is about 5,000 lbs.

The British America Nickel Corporation, at Nickelton, Ont, used a combination scale-charge-car, which is of the same length as the furnace and is divided into four compartments to correspond with the four charging doors.

Continuous feeding has been suggested as a possible way of improving blast-furnace practice, and would indeed seem to promise certain advantages, such as steadier blast resistance, better utilization of heat in escaping gas for pre-heating the charge, and greater uniformity in gas temperature and composition. These latter considerations are of special value where gas is treated for its sulphur dioxide content.

Incrustation, an unavoidable evil, is of several varieties and develops from different causes. A scab or crust forms from sticky, semi-fused material adhering to the jackets and is aggravated by fine sulphide. It usually extends from the tuyeres to the top of the charge and is entirely harmless at first, but must be taken in hand before growing too thick and restricting the descent of the ore. Undigested silica manifests itself in the form of heavy crusts. If it has accumulated gradually, the crust will be hard and dense, but if silica accumulates rapidly the crust will often be loose and porous, hardly a crust at all but rather a column of cold, raw charge that offers an easy escape for the blast. Barring down crusts gives only temporary relief unless they have been undercut. Lower crusts must be fluxed away if they are not to remain as foundations on which other crusts will soon spring up. A matte concentration charge can usually be counted on to relieve a badly crusted ore furnace by reason of its running with a cooler top and lower column. Soon after the charge is switched, crusts cool off and are more readily pulled down and broken up. In smelting crusts, allowance is made for their excess silica content.

Pyritic smelting campaigns are mostly terminated by incrustations, and are short, six weeks to two months being a common average, though occasional runs of six months or longer are recorded. Campaigns may be prolonged by freer use of coke, lime, or other flux, but such expense soon exceeds the cost of shutting down, digging out and starting up again. However, when the ore supply crowds the smelter, and the cry for tonnage is loud and insistent, the metallurgist is often forced to expensive measures to keep his furnaces in blast. To do the cheapest work the pyritic smelter should have spare units; the pyritic furnace should be of moderate length and provided with means for quick handling of jackets and ready disposal of furnace cleanings.

Several reasons favor having the slag and matte overflow at the end of a furnace instead of at the side, one being the securing of an equal number of tuyeres on each side, thus promoting equal distribution of blast. Another marked advantage is that both sides are free and cleared for action, in contrast with the other arrangement where the front side of a furnace is cluttered up with overflow spout, settler, launders, and other appurtenances, a serious interference in getting at a matte break-out, and a handicap in tuyere punching. No job around a furnace is more unpleasant than punching tuyeres on the front of a side-discharging furnace, where the puncher has his choice of standing on top of the settler, hot under foot and limited as to headroom, or getting down into the congested space between settler and furnace, cramped and exposed to danger of spout explosions. Attention to the tuyeres is a task of major importance, and, being laborious and disagreeable at best, requires proper working facilities.

Blast volume and pressure are valuable indices of internal furnace conditions. Where a furnace has its individual blower of known delivery, volume can be ascertained at the power house; otherwise it can be measured in the connection leading to the bustle pipe. For this purpose the Clark blast meter, a specially constructed pitot tube and Ellison gage reading "cubic feet of air per minute," has given satisfaction.

A common accompaniment of pyritic smelting is a heavy fall of low-grade matte that is thin and penetrating and has an unfortunate way of working to the very bottom of things and taking advantage of the slightest opportunity to escape. The furnace crucible cannot be lined with magnesite, owing to the destructive action of water from leaks in the jackets or the sole plate, and of course a magnesite crucible would preclude quenching a furnace with water before it is dug out. Chrome brick is best for this purpose, though a good firebrick will answer. Break-outs are most likely to happen between jackets near the sole plate, and unless checked at

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once nearly always result in a burnt jacket. The more jackets in the lower tier, the greater the number of potential danger spots. For instance, an end-discharge furnace with six jackets to a side will have a minimum of fourteen vertical joints, each a possible avenue of escape for matte. The better way, I believe, is to construct the crucible of low, horizontal jackets, as long as practicable to reduce the number of joints, or to use the single-sheet construction capable of being cooled by a water spray, and on top of this crucible structure rest the lower tier of vertical jackets which are then several feet above the sole plate and beyond the danger of break-outs.

Low-grade matte has a decided corrosive action on equipment with which it comes in sustained contact, and it is frequently discovered that apparatus that has been satisfactory for high-grade matte will not answer for low-grade. The problem has been met in different ways; in my own experience I have found the following to give satisfaction:

Breast jacket of converter copper cast about a double coil of extra-heavy pipe for cooling water, the opening being protected with chrome brick.

Overflow spout of flanged steel, water-spaced, and a detachable lip jacket of bronze. A brick pillar or saddle built under the spout at its junction with the breast will put an end to break-outs at this point.

Matte-tapping block—a magnesite brick imbedded in a plate of converter copper. The siphon tap used at Nickelton, described in the Engineering and Mining Journal of Aug. 20, 1921, was successful, and can be recommended either as a principal or auxiliary means of tapping.

The Application of Copper Refining Practice to Other Fields*

Electrolytic refining has attained its chief application and highest development in the metallurgy of copper. The very dynamo, the invention of which created the large-scale demand for high-conductivity copper, gave the means of producing it by electro-deposition, and electrolytic refining on a commercial scale was one of the first electrical industries to be developed, while it remains today by far the largest application of the electrolysis of an aqueous electrolyte.

The experience gained in this field has found wide application in the refining of other metals, such as silver, gold, lead, bismuth, tin, nickel, iron and zinc, and in the recovery direct from the ore by leaching of copper, silver, gold and zinc. The successful application of electrolysis to these different fields requires a rebalancing of the various factors discussed in previous articles by the author, the relative values of which are often greatly altered by a change of metal. In any given case we must take into account (1) competition from other processes, (2) acid radical to be employed, (3) temperature of electrolyte, (4) character of deposit, (5) resolution at the cathode, and (6) depolarization at the anode.

Competition

Electrolytic copper refining has no effective competitor in its own field. Fire refining makes a low conductivity product unless furnished with very pure raw material such as selected Lake "mineral," and the various selective methods of reverberatory treatment yield but a partial recovery of gold and silver.

In the leaching field electrolysis has to meet several competitive methods of reduction, notably precipitation upon iron. While a free acid equivalent by electrolyzing is returned to the cycle, there are usually serious handicaps imposed by large quantities of impurities which cause various troubles in the cells and which progressively accumulate unless some outlet is provided. Even where electrolysis is indicated, therefore, an iron precipitation plant is usually required as an adjunct, from 10 to 30 per cent of the copper being recovered as cement.

Electrolytic silver has to compete with the older sulphuric acid method of parting. The latter is easy to operate and ties up less silver, but it will not make a product so low in gold as the electrolytic. It is still indicated, however, for small plants or for those which are used spasmodically.

In the case of gold refining the question is almost wholly dependent upon the amount of platinum and associated metals present. If the original gold is free from this metal group, there is no object in tieing up the gold several days for electrolysis and further increasing the opportunities for theft. When but very small quantities of platinum and palladium are present, they may be satisfactorily collected by wet methods instead of by electrolysis at about equal expense. When the quantities are larger electrolysis is indicated.

Electrolytic lead has to compete with the very efficient Parkes process of refining. When all factors are considered, the justification for electrolysis appears to rest almost entirely upon the quantity of bismuth present in the bullion to be treated. This objectionable impurity is not satisfactorily removed by the Parkes process and special treatments such as Pattisonizing are expensive, while the electrolytic method readily separates the bismuth from the lead and converts it into a marketable byproduct.

Nickel, iron and zinc may be readily refined by electrolysis, but in ordinary times the value of the refined product, except in a very limited quantity, is not sufficiently above that of the crude to pay for the refining. Tin offers a special field for impure ores which are difficult to handle by fire processes.

In leaching, both nickel and zinc have strong competition from chemical and pyrometallurgical processes and this whole field is still in a state of flux.

In general, we can say that electrolysis enjoys no such absolute monopoly in other fields as it does in copper refining and that each proposed application must, therefore, receive full consideration upon its merits.

Acid Radical

While several salts of copper are suitable for electrolytic treatment, the sulphate possesses so many practical advantages that it is universally

*By Lawrence Addicks, in Chemical and Metallurgical Engineering, July 21, 1920.

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employed. The first requirement for an electrolyte is that the salt of the metal employed shall be readily soluble. The second is that the material which it is desired to collect in the slime shall be insoluble in it. The third is that the cathode should not be redissolved by the electrolyte. Copper sulphate is a readily soluble salt and copper, gold and silver are all practically unattacked by dilute sulphuric acid.

When electrolyzing silver a nitrate electrolyte is employed, as silver sulphate is not a readily soluble salt. The amount of free acid carried is necessarily low, as nitric acid is expensive and decomposes under the conditions of electrolysis. Copper concentrates in the electrolyte and is removed by withdrawals, while gold remains unattacked in the slimes.

In gold refining a chloride electrolyte is employed. Gold chloride is a soluble salt, platinum concentrates in the electrolyte, and although silver, being less noble than gold, dissolves at the anode, after saturation it precipitates as a secondary slime of insoluble chloride.

For lead, chloride and acetate were first tried, but not until Betts developed the fluosilicate electrolyte was the electrolytic refining of lead made a commercial success.

It will, therefore, be appreciated that an entirely new set of chemical conditions as regards behavior of impurities, etc., is encountered with every metal refined.

Temperature of Electrolyte

While it is customary to heat copper electrolytes externally, quite opposite conditions obtain in the case of silver, lead and zinc. Nitric and hydrofluosilicic acid show increasing decomposition losses with rise in temperature, asphalted tanks do not stand hot liquors and zinc resolution losses must be limited. In the case of silver, the current may have to be limited to control the temperature; for lead, extraneous heating is abandoned, and with zinc, where the specific resistance of the electrolyte is high, cooling systems carrying circulating water must be employed.

Character of Deposit

At moderate densities copper readily gives a good adherent deposit. The same may be said of gold. Silver gives normally a loose crystalline deposit. Nickel is nodular, while lead and zinc "tree" very badly. By the proper use of addition agents all of these deposits may be made smooth and coherent. In fact it was not until the value of addition agents was more or less understood that lead could be handled at all.

In the early copper plants a great deal of trouble was had in getting good starting sheets, and it was thought that the addition of ammonium sulphate was a help, the use of double salts being common practice in various electroplating prescriptions. Then the beneficial effect of the presence of wood strips on the edges of the starting blanks led to the introduction of wood tea made from shavings, yielding a complex organic addition agent. Finally the remarkable results following the addition of gelatine were worked out. The irregularities of early practice were due to overdosing and a failure to appreciate the fleeting effect of a single dose. Today a few pounds of common glue dissolved in water and added regularly throughout the twenty-four hours, together with a can of ordinary engine oil, will control the deposit in the tank house of a great copper refinery, permitting the use of higher densities, closer spacing and greater cathode age.

For silver, while adherent deposits can be made in similar fashion, it is customary to collect the silver crystals as such, either brushed to the floor of the tank from vertical cathodes by mechanical scrapers as in the Moebius system or shoveled by hand from the horizontal carbon cathode of the Thum cell. These crystals are readily washed free of electrolyte and fed to retorts for melting.

Lead may be beautifully controlled by addition agents. The exact amount to be added varies from time to time and is determined by experiment and careful watching of the fresh deposit on special strips hung for the purpose.

Zinc is generally plated in coherent form on an aluminum cathode, from which it is peeled every forty-eight hours. There is no reason why zinc starting sheets could not be used as in the case of copper, and in some ways the avoidance of a zinc-aluminum couple would be of advantage. In the development of electrolytic zinc practice, however, there has been great difficulty in controlling resolution at the cathode, and the great advantage of using aluminum sheets lies in the fact that strong corrosion can do no more than leave the starting sheets bare, whereas were they of zinc they might be completely eaten through, causing collapse, open circuits, general demoralization and shut-down of the plant.

Resolution at Cathode

The cathode is never absolutely insoluble in the electrolyte used and a small amount of reoxidation is always in process. In the case of copper with normal electrolytes it is a minor matter—perhaps 2 per cent. Should we allow an accumulation to take place of salts of manganese, iron or any other metal capable of alternate oxidation and reduction at anode and cathode with change of valence, a very serious condition may arise.

In these days copper anodes are so highly refined that the amount of iron contained in the electrolyte is quite negligible, but when electrolyzing liquors arising from the leaching of ore a very different situation exists. Such liquors commonly contain large quantities of ferrous sulphate and a certain proportion of ferric sulphate. Oxidation at the anode tends to increase the latter at the expense of the former. (See Addicks, Trans. Am. Electroch. Soc., vol. 28, p. 87.) Experiments show that 0.25 per cent of iron as ferric sulphate in an electrolyte sufficiently agitated will corrode cathode copper at a rate which will require a current corresponding to about 8 amp. per sq. ft. merely to replace the loss. The proper control of ferric sulphate is, therefore, the key to success in electrolyzing copper leaching liquors.

Another interesting example of resolution is in the case of zinc—in fact this is the controlling factor in zinc electrolysis. In the electrolysis of zinc sulphate using an insoluble anode the content of free sulphuric acid gradually increases and unless the cathode is absolutely pure zinc resolution is very active. Perfectly pure zinc is so nearly insoluble in sulphuric acid that it is quite difficult to get it in solution for analysis. But if a nodule of cathode zinc is immersed in dilute sulphuric acid in a test and the nearest trace of almost any impurity is added, a vigorous evolution of hydrogen will start at once. This is probably due to galvanic action,

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and the whole secret of successful zinc electrolysis lies in the passivity of pure zinc in sulphuric acid. This calls for a degree of purity in the electrolyte which would be quite uncommercial were it not for the fact that zinc dust readily throws down most of the impurities to be dealt with after the liquor from the leaching tanks has been neutralized. The last traces of some difficult elements, such as arsenic, are removed by absorption upon freshly made ferric hydrate.

Depolorization at the Anode

Anode efficiency plays a relatively small part in normal copper refining; the proportion of impurities present in the anode is small and the useful anode efficiency very high. As soon as a complex or insoluble anode is substituted, however, the oxidizing effect of the current is in part or in whole employed in the solution of anode impurities, the oxidation of suitable salts in the electrolyte or in the decomposition of water with escape of oxygen as such. This introduces several new problems.

A moderate amount of an oxidizable impurity, such as nickel, in a copper anode gives the first and simplest case. The nickel and copper dissolve proportionately at the anode, sharing the current. At the cathode, however, only copper is deposited, so that the copper in the electrolyte is correspondingly depleted. About 2 per cent of the copper deposited is restored by purely chemical solution at the electrodes but beyond that figure soluble copper must be added by leaching shot or scale, and the accumulating nickel must be controlled by withdrawals to a byproduct plant.

The second difficulty arises when the quantity and nature of the impurity in anode causes segregation into two components one of which is more readily dissolved than the other. Then the anode disintegrates unevenly and a large amount of scrap has to be reworked.

A third and more serious condition is met with when the impurity is insoluble, such as lead or antimony, when the anode will become coated with a non-conducting slime. The voltage will then rise until some free oxygen is generated from the moisture underneath. This in turn will burst through the coating and the anode will act normally for a few seconds, when the coating will again form. A voltmeter connected across such a tank will show a wildly fluctuating needle, and this condition, known colloquially as "crazy tanks," is fatal to good refining, entailing as it does excessive gold and silver losses in the cathode, high power cost and a heavy expense for purifying electrolyte. The remedy lies in properly refining the crude material before casting the anodes.

Finally, we have the extreme case where the anode is by intent insoluble, as where copper is being recovered from leaching liquor. Where no depolarizer is employed, the voltage must of course be sufficiently high to decompose water, and free oxygen is given off at the anode. When the liquor is virtually free from chlorides and nitrates, antimonial lead is generally used as the anode material; when electrolyzing zinc, however, pure lead is required in order not to poison the cathode with specks of antimony. When the liquor is corrosive, either magnetite or one of the ferro-alloys, generally ferrosilicon, is employed. None of these anode materials is wholly free from oxygen attack. Lead peroxidizes and sulphatizes and the iron alloys slowly dissolve, so that a certain replacement charge must be reckoned with.

Where an efficient depolarizer is employed, any of the materials mentioned above or carbon may be employed. Graphite offers peculiar advantages in that 100 per cent of efficiency of oxidation of ferrous sulphate or similar depolarizer is readily obtained by its use. Lead does not give equal results. On the other hand carbon itself will oxidize and disintegrate if not fully protected by the depolarizer. This whole question of a cyclic oxidization at the anode with subsequent reduction at the ore contact is yet in but partially developed form, most of the theoretical advantages being generally offset in practice by the difficulties met with in handling impurities dissolved from the ore.

CALCULATION OF ANODE FURNACE CHARGES IN A COPPER REFINERY*

"Get the silver and gold into the anodes as quickly as possible" is the governing principle for the copper refinery. Every day that the precious metals are locked up in the pig copper means a real loss to the plant in the interest on the money value. Once in the anodes, a start, at least, is made on the road to final shipment as refined metal. Plants doing custom work are required by their contracts to deliver the silver and gold received in pig copper to the owners within a certain specified time—usually about two months after receipt. The refinery must deliver the goods on the specified date or transfer the money equivalent to the owner.

Some one man must keep the bullion moving, therefore, and calculate the anode-furnace charges, to assure that the richer blister copper is given first place in the mixture. The procedure described in this article is that practiced by a large copper refinery in this country.

*By C. M. Brister, Jr. Written for Engineering and Mining Journal.

Equivalent Silver in Various Brands is Recorded

For quick comparison of the various grades of copper received, a list showing the "equivalent silver" of each brand is kept up to date by use of the latest assays available. The term is simply a figure showing the value of the precious-metal content of the blister, considered as all silver. That is, with gold at $20 per troy oz. and silver at $1 per oz., the equivalent silver for pig copper assaying 0.5 oz. gold per ton, and 25 oz. silver per ton, will be $0.5 \times 20 + 25 \times 1 = \$35$.

ASSAY OF VARIOUS HYPOTHETICAL BRANDS

Brand	Gold, Oz. per Ton	Silver, Oz. per Ton	Equivalent Silver, Value in Dollars per Ton
A	4.50	630	720
B	0.80	400	416
C	1.00	150	170
D	0.65	67	80
E	0.98	55	75
F	1.00	40	60
G	0.85	2	19
H	0.15	13	16

A copy of this list is sent to the anode-furnace superintendent for his guidance. If "G," for ex-

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ample, appearing on his charging instructions, is not available for any one charge, he will consult the table and substitute the brand highest in value and which is not carrying more impurities than "G."

This table is brought up to date once a month, with the aid of the average assays of each brand received during the month. The variation in value and percentage of impurities for any particular blister is usually slight, so that if a high-grade lot comes in and no provision is made for it on the current charge, it can be immediately taken care of by using the analysis and assays of the preceding month. It must be drilled for the sample, but it is not necessary to wait for the assay of the sample. In the treatment of blister which varies widely from month to month, a hurried drill sample is usually taken to check the assumed assay values, whenever a new lot comes in.

The factors other than equivalent silver which affect the choice for the charge are:

1.—Impurities. Typical analyses of the ten brands enumerated in the equivalent silver table may be:

	Assay in Per Cent.					
Brand	Lead	Nickel	Arsenic	Antimony	Selenium	Tellurium
A	0.550	0.525	1.425	0.440	1.350	0.540
B	0.330	0.430	0.370	0.230	0.030	0.008
C	1.800	1.140	0.310	0.460	0.032	nil
D	0.025	0.067	0.002	0.070	0.020	0.007
E	0.004	0.058	0.001	0.002	0.035	nil
F	0.010	0.014	0.004	0.003	0.015	0.010
G	0.009	0.030	0.010	0.013	0.030	0.012
H	0.008	0.042	0.020	0.055	0.007	nil

The impurities in a particular brand of pig copper usually run fairly uniformly, and in most operations there are one or two impurities which will limit the amount of that brand to be placed in the anode charge. The copper having the highest equivalent silver is used up to the limit of the amount of impurities the charge will stand.

All reports within the plant show the "Stock on Hand" and other pertinent information of each brand, in tons. It greatly facilitates calculations, therefore, to have the impurities listed as **pounds per ton,** instead of in per cent. A loose-leaf record is kept with a separate sheet for each impurity, as follows:

NICKEL IN PIG COPPER
In Pounds, Per Ton

Brand	Average Aug.-Jan.	January	Average Sept.-Feb.	Feb.	Average Oct.-March	March	Average No.v-April
A	10.50	.....	10.50	....	10.50	10.50	10.50
B	8.00	7.50	7.92	8.20	7.95	8.60	8.06
C	45.00	22.60	26.33	....	26.33	22.80	25.74
D	1.20	1.20	1.20	1.28	1.21	1.35	1.23
E	1.30	1.44	1.32	1.38	1.33	1.16	1.30
F	0.28	.....	0.28	....	0.28	0.28	0.28
G	0.60	0.58	0.60	0.62	0.59	0.60	0.60
H	0.98	1.02	0.99	1.02	1.00	0.85	0.98

The average column shows the average value for the last six months. It is a most convenient figure to have when a lot of high-grade copper arrives in the middle of a period, for it can be used in calculations of a new charge until more accurate figures are available.

The allowable limits of impurities in the anodes depend upon the pig copper available for use. The permissable limits may be as listed below:

ALLOWABLE LIMITS OF IMPURITIES IN ANODES

	Maximum, Per Cent.	Minimum, Per Cent.
Gold	.....	0
Silver	225 oz. per ton	0
Lead	0.150	0
Nickel	0.155	0
Arsenic	0.150	0
Antimony	0.120	0.08
Selenium	0.10	0
Tellurium	0.05	0

It is not good practice to have the results of the charge calculations show the maximum figure for more than two impurities on the same charge. There are impurities present, of course, other than those listed, but their importance is negligible so far as the average tank house is concerned.

2.—Rate Received and Sampled. This factor is often of primary importance in the treatment of high-grade pig copper, where every pig is drilled for sample. Obviously, the rate at which it may be used in the furnace is limited by the speed of the drilling. With blister not especially high in precious metals it is generally convenient to use the copper on the charge at a rate that will compensate for receipts, and thus save the expense of handling to storage and back to cars again.

3.—Amount on Hand. When the receipts exceed the consumption there is an accumulation at the stockpiles. When the receipts fall off or the consumption increases, the amount of each brand designated for the anode charge is proportioned to accommodate the accumulation as well as receipts, in those instances where the equivalent silver so warrants.

4.—Storage Facilities. It is often necessary to use a brand the equivalent silver of which would not justify its use at the time, simply because of lack of space in which to store receipts. It must go directly from the sample drills to the anode furnaces.

5.—Availability. Occasionally a large quantity of low-grade copper is received and has to be stored in any available space. This may completely block off some higher-grade blister, which then cannot be used until sufficient of the low-grade material has been removed to free it again.

6.—Physical Character. The shape, or the "top set," of the pigs may be such that they cannot be piled and transported except with the greatest care, and even then frequent spills may happen. In such circumstances only a certain amount of the blister can be used on the charge without excessive cost or delay in the charging—no matter what the amount of the equivalent silver may be.

Before calculating the charge, the operator must know the "furnace factor." By this term is meant a number which, multiplied by the total weight of any impurity going into the anode charge, will give as a product the weight of the impurity in the anodes cast from the charge. The factor may be calculated by carefully listing the weights of all items entering the furnaces for a period of, say, ten days. The amounts of the impurities are listed in columns, and the totals made, giving the weight of each impurity entering the charge. The average percentage of each is then calculated and compared with the corresponding figures actually found by analysis of the anodes produced from the charges for the same ten-day period. The actual percentage, divided by the calculated percentage, will give the factor desired. The following calculation is an example:

ANALYSIS OF CHARGE

Brand	Tons Charged	Contents of Charge, Pounds Lead	Nickel
A	150	1,650	1,575
B	250	1,650	2,150
C	25	900	570
D	500	250	675
E	100	8	116
F	125	25	35
G	125	23	75
H	600	96	504
Anode scrap	625	563	1,750
Totals	2,500	5,165	7,450

Average lead, 5,165 ÷ 5,000,000 = 0.103 per cent.
Average nickel, 7,450 ÷ 5,000,000 = 0.149 per cent.
Results actually found by analysis of the anode samples: Lead, 0.056 per cent.; nickel, 0.153 per cent.
Factor for lead, 0.056 ÷ 0.103 = 0.54.
Factor for nickel, 0.153 ÷ 0.149 = 103.

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Factors for arsenic, antimony, and the other impurities are similarly calculated.

Calculating the Charge

Suppose, on the first of the month, the stock sheet shows:

Brand	Tons on Hand, 1st	Expected to Arrive 1st to 10th	10th to 20th	20th to 1st
A	200	300	200	0
B	372	250	250	250
C	1,117	250	250	250
D	739	955	300	250
E	188	125	100	100
F	511	0	0	0
G	154	0	0	0
H	8,622	0	0	0
Totals ..	11,903	1,880	1,100	850

The multiple tank house is operating at 7,000 tons per month. The anode furnaces will make one charge of 250 tons per day for the next ten days. This will mean 25 tons for each per cent of each kind of blister on the charge. The tank-house scrap, which may be assumed to average 25 per cent, must also be treated.

If impurities were all allowed to the maximum percentage, the following amounts could be present:

(1) Element	(2) Allowable	(3) Factor	(2)÷(3) Quotient	(4) Lb. per Ton	(4)×7,000 Total Lb.
Lead	0.15%	0.54	0.28%	5.6	39,200
Nickel	0.155	1.03	0.15	3.0	21,000
Arsenic	0.15	0.92	0.163	3.3	23,100
Antimony	0.12	1.11	0.108	2.1	14,700
Selenium	0.10	0.93	0.107	2.14	14,980
Tellurium	0.05	0.63	0.079	1.5	10,500

Enter the anode scrap on the estimate sheet. With this taken care of, the operator is still allowed:

	Lb.		Lb.
Lead	37,625	Antimony	11,720
Nickel	16,100	Selenium	13,055
Arsenic	19,070	Tellurium	9,975

Considering the brands in the order of their equivalent silver:

"A." The important factor here is **Impurities.** Arsenic and selenium limit the amount to be used, and since there is an allowance of 6,500 lb. more of the former than the latter, the selenium governs. Each per cent of "A" on the charge is equivalent to $70 \times 27 = 1{,}890$ lb. of selenium. About 6 per cent, therefore, is all that can be used. With this amount on the charge, there is left an allowance of:

	Lb.		Lb.
Lead	33,005	Antimony	8,020
Nickel	11,690	Selenium	1,735
Arsenic	7,090	Tellurium	5,435

"B." Here again the important factor is **Impurities.** After an examination of the impurity table, it is apparent that arsenic will limit the use of this brand. Each per cent of "B" is equivalent to $70 \times 7.4 = 518$ lb. of arsenic. About 10 per cent of "B" can be taken care of with safety, leaving an allowance of:

	Lb.		Lb.
Lead	28,385	Antimony	4,800
Nickel	5,670	Selenium	1,315
Arsenic	1,910	Tellurium	5,323

"C." The controlling factors here are **Impurities** and **Availability.** On account of the excessive amount of impurities, this blister is given a preliminary furnace refining before being used on the anode charges. The operator has to consider only the skulls and other scrap resulting from the casting, amounting to about 1 per cent on the anode charge. This leaves an allowance of:

	Lb.		Lb.
Lead	25,865	Antimony	4,166
Nickel	4,074	Selenium	1,271
Arsenic	1,476	Tellurium	5,323

"D." The small remaining allowance of selenium will limit the use of "D." One per cent of "D" is equivalent to $70 \times 0.4 = 28$ lb. of selenium. About 25 per cent may be used, leaving an allowance of:

	Lb.		Lb.
Lead	24,990	Antimony	3,921
Nickel	1,714	Selenium	571
Arsenic	1,389	Tellurium	5,078

"E." This is a very pure blister, and ordinarily the **Rate Received** and the **Amount on Hand** would govern, but since there is such a small remaining allowance of selenium, the amount that it is possible to use will be limited to about 6 per cent, leaving an allowance of:

	Lb.		Lb.
Lead	24,957	Antimony	3,904
Nickel	1,224	Selenium	277
Arsenic	1,381	Tellurium	5,078

"F." **Availability** must govern the use of this blister—it is not available because the entire lot is surrounded by "H."

"G." The **Amount on Hand** is the ruling factor. Allowing 6 per cent to use up the entire lot in the next ten days leaves:

	Lb.		Lb.
Lead	24,881	Antimony	3,795
Nickel	972	Selenium	25
Arsenic	1,297	Tellurium	4,977

"H." This will complete the charge with 21 per cent. Under other conditions the **Physical Character** might be the limiting factor with this brand. The pieces have rounded bottoms and are, therefore, very hard to pile. The limit for the furnace ordinarily is about 40 per cent. Above this figure, its use will seriously delay the furnace working.

After the calculation is completed, instructions are sent to the foreman of the anode furnaces, giving the name and percentage of each blister for the anode charge and the estimated analysis of the resulting anodes. Copies of these memoranda are sent to the tank-house foreman, the yard foreman, and all others concerned.

The actual work involved in the calculation is not nearly so intricate as it may seem, when the necessary records and other information are kept up to date. Slide-rule calculations are permissible.

ESTIMATE SHEET, MULTIPLE ANODE COMPOSITION

Brand	Per Cent.	Tons	Gold Oz. per Ton	Gold Total	Silver Oz. per Ton	Silver Total	Lead Lb. per Ton	Lead Total	Nickel Lb. per Ton	Nickel Total	Arsenic Lb. per Ton	Arsenic Total	Antimony Lb. per Ton	Antimony Total	Selenium Lb. per Ton	Selenium Total	Tellurium Lb. per Ton	Tellurium Total
Scrap	25	1,750	0.87	1,520	100	175,000	0.9	1,575	2.8	4,900	2.3	4,030	1.7	2,980	1.1	1,925	0.3	525
A	6	420	4.5	1,890	630	265,000	11	4,620	10.5	4,410	28.5	11,980	8.8	3,700	27.0	11,320	10.8	4,540
B	10	700	0.8	560	400	280,000	6.6	4,620	8.6	6,020	7.4	5,180	4.6	3,220	0.6	420	0.16	112
C	1	70	1.0	70	150	10,500	36	2,520	22.8	1,596	6.2	434	9.2	634	0.64	45	nil	nil
D	25	1,750	0.65	1,140	67	117,000	0.5	875	1.35	2,360	0.05	87	0.14	245	0.4	700	0.14	245
E	6	420	0.98	411	55	23,100	0.08	33	1.16	440	0.02	8	0.04	17	0.7	294	nil	nil
G	6	420	0.87	357	2	840	0 18	76	0.6	252	0.2	84	0.26	109	0.6	252	0.24	101
H	21	1,470	0.15	220	13	19,100	0.16	235	0.84	1,230	0.4	588	1.1	1,617	0.14	206	nil	nil
Total ...	100	7,000		6,168		890,540		14,554		21,258		22,391		12,522		15,162		5,523
Avg. oz. or lb. per ton.....			0.88		172.2		2.08		3,037		3,199		1,790		2,166		0.790	
Per cent.			....		.....		0.104		0.152		0.160		0.089		0.108		0.039	
Furnace factor			1.0		1.0		0.54		1.03		0.92		1.11		0.93		0.63	
Estimated analysis, oz. per ton or per cent.....			0.88		127.2		0.056		0.157		0.147		0.099		0.100		0.025	

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PULVERIZED FUEL

Powdered coal for metallurgical use dates back about 90 years. Its growth in competition with fuels of other forms has been slow, owing to difficulties experienced in pulverizing cheaply, conveying economically and properly burning the coal. A further difficulty was the failure to exercise proper control in the burning, because the importance of the form of burner and the method of feeding the fuel to furnace were not understood.

In the past few years much has been learned on these matters, and so much has been done in the way of improving methods and devices that pulverized coal is now used in practically all branches of the industry where a high temperature is required, one company alone having 77 furnaces in operation.

SOME APPLICATIONS OF PULVERIZED FUEL

Boilers

The difficulties first encountered in the application of powdered fuel to boilers were largely due to incorrect furnace design, not only as regards the general form, but also the proposition to meet load conditions, characteristics and analyses of fuels. The earlier trials were made with bituminous or sub-bituminous coals, and as general knowledge of the subject became available, larger projects were undertaken until at the present time there are a number of plants which are of sufficient size and importance, burning pulverized bituminous and anthracite coals and lignite, to furnish a good comparison with similar stations equipped with stokers. As a result of careful testing and comparison, it has been demonstrated that powdered fuel for steam generation has the following advantages:

1. Varying load conditions can be almost instantly met by increasing or decreasing the supply of powdered fuel, which is controlled as readily as fuel oil or gas.
2. The fire can be ignited and the boiler plant put on the line in a few minutes.
3. Average efficiencies are considerably higher, due to the perfect control of the fuel.
4. Ability to burn any grade of pulverized fuel, irrespective of ash content or its point of fusion and percentage of fixed carbon.

Portland Cement Kilns

The first successful application of the use of pulverized coal in the industries was in this field. The cement industry is now the largest single user of pulverized fuel, the consumption in the United States alone being more than 5,000,000 tons per year.

It is claimed that a great part of the success of the rotary kiln in this industry is due to the use of powdered coal as a fuel.

Smelting and Refining Furnaces

Pulverized fuel is increasingly used in copper reverberatory furnaces, sintering machines, roasters, arsenic kilns, assay office furnaces and lead blast furnaces.

Pulverized fuel is injected through the blast furnace tuyeres, resulting, it is claimed, in a 25% saving in coke consumption.

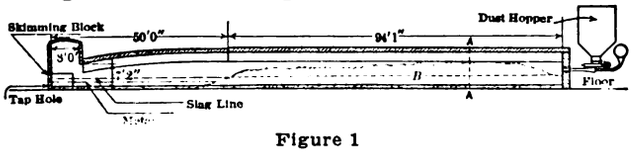

Figure 1

The Anaconda Company made their first change to the use of powdered coal in reverberatory furnaces in the month of June, 1914, after an investigation of a similar installation at the Copper Cliff plant of the Canadian Copper Company in Ontario.

The first furnace, as remodeled, was 124 ft. long by 21 ft. wide, varying in height from 8 ft. 6 in. at the back end to 5 ft. 7 in. at the skimming end. The next furnace built was 144 ft. long by 25 ft. wide, inside dimensions; 9 ft. 3½ in. high at the back and 6 ft. 6 in. at the front; flues are 48 sq. ft. in area. Figures 1 and 2 show the general construction.

The charging is done on either side of the furnace from longitudinal hoppers extending a distance of 74 ft. from the back end of the furnace.

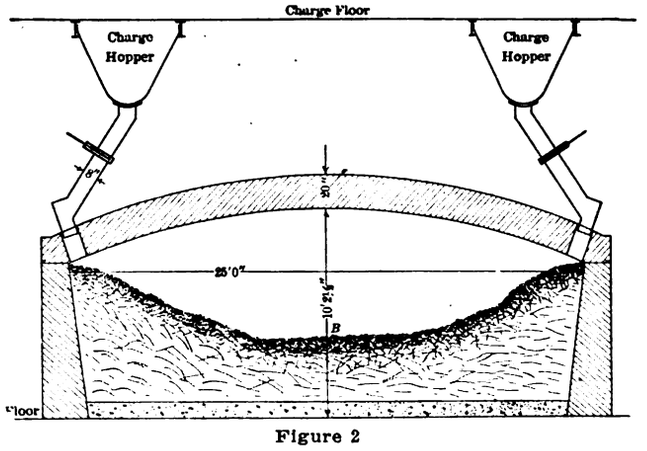

Figure 2

According to the Anaconda authorities, after observation of the results obtained with their first installation, the following conditions are imperative to obtain successful results in coal dust firing:

1. Coal must be dried down to 1% or less moisture before pulverizing. The furnace is the most expensive place to dry coal.
2. The coal must be finely pulverized. In crushing, the total surface of a pound of coal is increased from one-quarter of a square foot, in a single lump, to 8,000 square feet, more or less, when crushed 82% through 200 mesh, which is 10% or 11% finer than has been found necessary for the most complete combustion.
3. The proportion of air to coal delivered to the furnace must be properly controlled. Any air in excess of the amount necessary to obtain the desired results dilutes the gases and reduces the temperature. Insufficient air means production of CO, which means incomplete combustion.
4. The coal must contain enough volatile combustible matter to give the required combustion. In cement kilns, coal containing as low as 22% V.C.M. has been used. James Lord, of the Amer-

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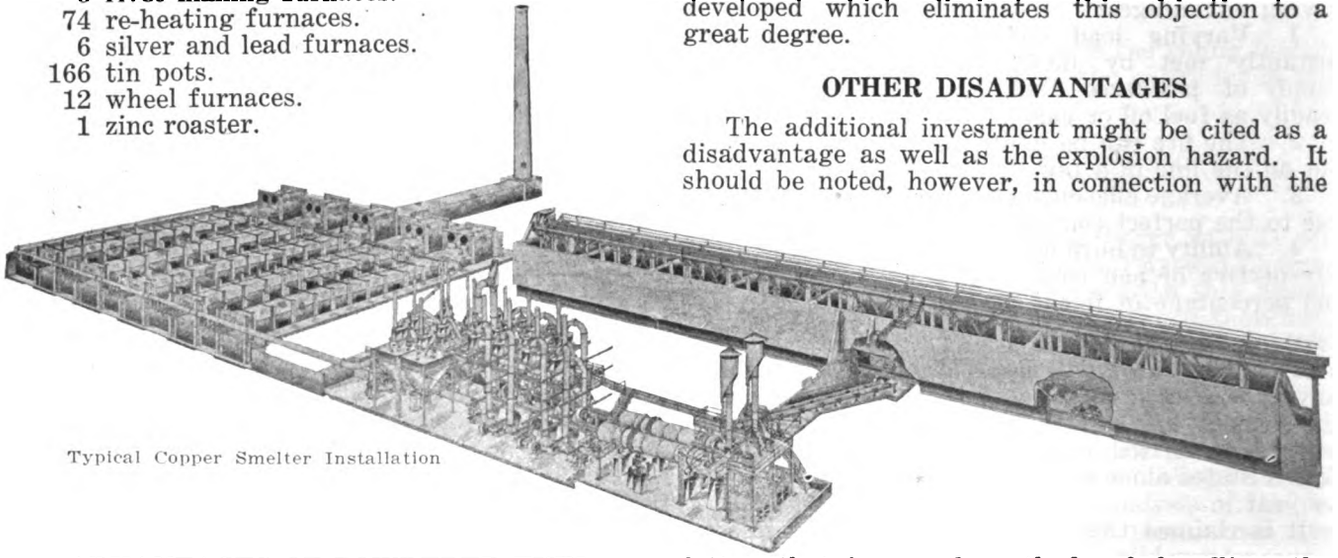
ican Iron & Steel Company, recommends 30% as a minimum.

5. The furnace must be properly proportioned, properly equipped and in good condition.

6. Provision must be made for taking care of the ash formed.

According to data compiled by C. F. Herrington, author of "Powdered Coal as a Fuel," the various kinds of metallurgical furnaces using pulverized coal made a grand total of approximately 2000 at the end of the year 1921, divided as follows:

4 air furnaces.
158 annealing sheets.
226 annealing malleable castings.
2 bloom furnaces.
20 busheling furnaces.
2 core-oven furnaces.
44 continuous furnaces.
10 casting furnaces.
16 copper reverberatory furnaces.
21 electrode furnaces.
622 forging furnaces.
2 gun shell furnaces.
306 hot mill furnaces.
6 kilns.
24 malleable melting furnaces.
37 nut and bolt furnaces.
17 open hearth furnaces.
38 puddling furnaces.
9 rolling mill furnaces.
6 rivet making furnaces.
74 re-heating furnaces.
6 silver and lead furnaces.
166 tin pots.
12 wheel furnaces.
1 zinc roaster.



Typical Copper Smelter Installation

ADVANTAGES OF POWDERED FUEL

High Combustion Efficiency

This is especially evident in boiler installations where it is easy to make comparisons.

Even with comparatively low grades of fuel it is possible to burn fuel with less than 2% loss of combustible matter in the ash with bituminous, and less than 5% with anthracite coal. This is done with only 10% to 15% of excess air.

In ordinary practice, the amount of combustible matter in the ash ranges from 15% to 50% and the excess air required is from 75% to 150% in hand firing and 50% to 75% with stoker firing. This reduction in excess air together with the fact that there is no bed of fuel through which the air must pass, with resultant drop in pressure, makes possible the use of much smaller draft equipment.

Heating of excess air where lump coal is used is responsible for lower efficiency. Boiler efficiencies of over 80% are claimed for pulverized fuel.

Use of Low Grade Fuels

Even with all drying and pulverizing costs, which must be offset by the lower cost of the fuel, it is true that in many cases the lower grade fuel can be burned economically in many cases at a lower cost than a higher grade of coal used in lump or slack form. The quantity of these low grade fuels is tremendous, especially in the Western states, where so much of the coal supply consists of sub-bituminous and lignite coals.

"Stand-By" Losses

These are obviously less, due to ease of control, particularly where it may be desirable at short notice to vary the load on a boiler installation or the temperature of a metallurgical operation.

DISADVANTAGES

Grinding or Pulverizing

The necessity for fine grinding with more or less complicated machinery, involving the employment of skilled mechanics for repair work and loss of operating time up to 25% or more, has caused operators to doubt the commercial practicability of burning pulverized fuel.

It is claimed, however, that machinery has been developed which eliminates this objection to a great degree.

OTHER DISADVANTAGES

The additional investment might be cited as a disadvantage as well as the explosion hazard. It should be noted, however, in connection with the latter, that improved methods of handling the powdered fuel have practically eliminated the danger.

The Pulverizer

The pulverizer is the most important part of the equipment of a pulverized fuel plant. It must be well built, dust-proof and economical in power consumption, since the power required in grinding is equal to if not greater than that required by the balance of the equipment in the entire pulverized fuel plant.

While it is theoretically true that the finer the fuel the more efficient the burning, other conditions occur in the process of burning which make extremely fine pulverizing a waste of energy. It has been found that bituminous coal need not be pulverized finer than 90-95% through 100 mesh, and 70-75% through a 200 mesh screen, and that

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anthracite coal and coke need not be finer than 85% passing 200 mesh.

The amount of "coarse oversize" governs to a large extent the economical grinding limitations rather than the average fineness. Particles of oversize in bituminous coal should not be coarser than 65 mesh, and in anthracite coal or coke coarser than 80 mesh, for if larger particles do occur they drop out of the combustion zone before all of the combustible has been consumed.

The maintenance of a uniform product free from coarse oversize is of vital importance and controls the combustion efficiency to a great extent.

Grinding must be carried out in a logical manner to produce results commensurate with the energy expended. Authorities on methods of pulverizing materials recognized:

(a) That reduction should be effected in steps or stages.

(b) That material which is sufficiently fine should be removed as soon as reduced to this fineness.

(c) That the force exerted should be proportional to the work required.

In grinding materials the particles undergoing reduction shoud not become imbedded with other particles already pulverized, or more energy will be required to effect their reduction, due to the necessity of beating through the mass until the few remaining particles have been reduced. On the other hand, if the fine material has been removed and the larger particles exposed, their reduction will then be a simple matter.

It will be found that all successful grinding processes recognize this principle.

TRANSPORT SYSTEMS*

Fuller System

The emulsion system is the latest application of pneumatic distribution just developed beyond the experimental stage. It is based on the principle that air produces an emulsion with pulverized coal; in other words, a small amount of air, thoroughly mixed with an impalpable powder, produces a heavy fluid mass that flows and throws waves like water, that can be stirred by a stick like a fluid, that feels fluffy and light. It seems that each particle of coal is surrounded by a tiny air volume which reduces the friction of the solid matter and counteracts the viscosity of surface tension. This fact has been known for oils and liquids, and is utilized commercially in several interesting applications, but for pulverized solids it had been overlooked until lately. The remarkable qualities of emulsive mixtures open new possibilities to the pneumatic transportation methods, as powdered coal emulsions flow like heavy oil and can be pumped like a fluid.

In its actual patented form the emulsion transport consists of a hopper feeding by gravity, a screw conveyor provided with a helix of variable pitch, rotating at high speed in a circular shell. The coal is compressed in this conveyor and delivered to the nozzle, where a certain number of air jets produce the emulsive mixture which starts to flow through the pipe line, pushed by the constant pressure of the screw. An adequate system of gates and switch-valves gives to the system flexibility and adaptability. No cyclone separators are necessary, because the amount of air is too small for their action, less than ⅓ cu. ft. of air being required per pound of coal to emulsify pulverized fuel. The air pressure depends on the nature of the coal and the length of the transportation, and varies from 15 lbs. to 50 lbs. per sq. in. The diameter of the screw and the diameter of the pipe govern the capacity of each system, which changes with the length of transportation. The power consumption per ton of coal is very small. As built today, the emulsion system is not purely pneumatic, the pressure of the screw conveyor, being a mechanical force, causing the flow of the mass. The efficiencies obtained today are high and with further study and research can doubtless be greatly improved.

The emulsion distribution system is too new to permit critical comparisons and to assign to a special field. The cost of distribution is very difficult to express in dollars and cents, and it is very hard to give reliable figures on that subject. Local conditions vary and influence this item so much that generalities are misleading. In all fairness it must be said that the pneumatic distribution systems have progressed considerably, and in their present form are far superior to the mechanical devices. When it comes to the choice between systems it will be well to remember that no absolute superiority exists and that local conditions alone will decide on the most practical solution. Combinations of the various systems described above may be profitable and economical.

Quigley System

The pressure method of transportation uses the static pressure of the air and not its dynamic impact as motive force. The coal is not mixed with air, but pushed through the pipe line by pistons. The action can be compared to the mail tubes, where cylinders are shot through the conduits by a similar effect. The system consists of an air-tight tank, provided with suitable valves for the introduction of the coal with an inlet connection for the pressure of air and an outlet connection for the delivery pipe, the transport line with the necessary switching valves and cyclone separators over the furnace bins.

The volume of air per pound of coal is very small, therefore small pipe areas are required, ¾ in. to 1½ in. for air line and 2 in. to 6 in. for delivery line. The diameter of the transport pipe governs largely the amount of coal shot through the system, while the pressure of the air limits the distance of distribution. Sharp bends and angles in the pipe line ought to be carefully avoided and air-tight joints are absolutely necessary for reliable operation.

Distances up to 1,500 yds. have been successfully covered with an air consumption varying between 1 and 4 cu. ft. per lb. of coal at pressures between 15 and 20 lbs. per sq. in.; quantities like 3,000 lbs. have been rushed through a 4 in. pipe in about 1 minute at a distance of 500 ft. These figures are merely indicative; they have no other purpose than to reflect the economies and results obtained. Thermodynamic calculations show that the efficiency is very low and suggest that considerable improvements remain possible.

*By Joseph Shadgen, Con. Eng., in Iron Age.

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By providing two pressure tanks and operating them alternately in conjunction with scales preferably of the recording type, the pressure system gives a constant delivery with easy checking and control at each furnace. The cost of installation of the system is low, but the individual bins and feeders at each furnace are required which have to be taken into account in comparisons. The amount of air is small, but its high pressure necessitates an air compressor. Explosions are excluded, as the air and coal are not mixed.

The pressure method is recommendable for distribution over long distances to large furnaces. Outside of that field knowledge of the exact local conditions is necessary to give correct advice.

The Holbeck System

The suspension method of distributing fine powder moves the solid particles suspended in an air current. To obtain this effect, two things are required: first, the ratio of the air stream must be so high as to overcome the weight of the solid at any point of the circuit.

This system has been very popular in the last few years, and consists essentially of a large pipe line 8 in. to 20 in. in diameter, varying with the amount of coal to be distributed, a high pressure fan producing the velocity of the circulating air, and a feeding device for the fuel. The coal-air mixture is tapped from the main line by valves into side pipes leading directly to the combustion chamber of the furnaces and a return pipe brings back the surplus coal to the main storage bin, thus avoiding all losses. The relation of coal to air can be made a constant, variable within limits by making the coal feeding devices dependent upon the volume or the velocity of the air currents. The ratio of the mixture varies usually from 35 to 70 cu. ft. of air per lb. of coal; in other words, from ¼ to ½ of the air required for complete combustion of the coal, and the velocity of the current usually oscillates between 5,000 and 6,000 ft. per minute.

This system, correctly designed and properly installed, gives excellent service. It has the advantage of centralized control for a certain number of furnaces, and this quality makes it suitable, for instance, in forges with their numerous small fires because no individual bins and separate feeders are necessary. The cost of installation is low and the upkeep reduced, as the fan motor is the only wearing part.

The main defect of the system is the high power cost of the fan on account of the high velocities. Furthermore, the length of the circuit is physically limited. Beyond certain distances, to avoid dust deposits and the possibility of choking the pipe, relay stations with additional fans have to be installed. The coal air mixture is within the explosibility limits and, therefore, great care should be taken; absolute tightness of pipe line is essential, and proper precautions should prevent all possibilities of ignition.

Heyl & Patterson Company System

This is called, by the Heyl & Patterson Company, the "closed circuit" system. It involves an automatic control of the amount of coal and air in the system, the amount of coal being that necessary to procure the desired results; the amount of air to be less than that required to support combustion.

This "sealed circuit" has no outlet to the air, preventing the distributing pipes from acting as a stack to carry heat or flame from the furnaces when the fan stops.

Coal and air once mixed are circulated until burned, preventing the concentration of larger particles in the hopper. The manufacturers claim this system to be "explosion-proof."

The amount of coal and air introduced into the system at any one time depends upon the intensity of the vacuum created in the carburetor by the blower. As more or less coal is consumed, the air valve in the carburetor is opened or closed and the speed of the controller is increased or decreased to meet requirements. The coal and air in the mixture are practically constant irrespective of the amount of coal consumed. Any surplus coal and air in the system is automatically by-passed to the cyclone separator located over the fuel storage hopper. This by-pass valve is operated with solenoid control interlocked with the carburetor operating mechanism in such a manner that the valve will be closed at all times except when the controller is running at minimum speed. The valve in the by-pass line closes automatically whenever the power circuit to the blower is opened, whether by accident or intent of operator.

SEPARATORS

Several types are available for different uses.

Some pulverizers require a cyclone separator for the separation of oversize for return to the machine.

Dryers also require a cyclone separator to collect the dust carried off with the moisture as the air passes through the coal being dried. A separator is also sometimes required over the furnace hopper to separate the coal from the transport air.

DRYER

Any dryer can be used which eliminates the danger of ignition of dust. This danger can be avoided only by reducing the temperature of the gases to about 270° F. before they come in direct contact with fuel.

EXHAUSTERS

Exhausters if used in connection with the dryer should be built in sizes to suit the dryer capacity and control the volume of air passing through it.

Blowers are used at the furnace to supply air for combustion. Best results are obtained by positive control and close regulation of the air supplied to the furnace.

Either "high pressure" or "volume" types of blowers may be used. The "high pressure" type supplies air (at pressures up to 8 ounces) for carrying the fuel from the powdered coal feeder to the burner. The "volume" type supplies, at a very low velocity, the additional air necessary to complete the combustion. In many plants sufficient compressed air is available from present sources so that additional capacity is not required.

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FEED CONTROLLERS

Feed controllers must be readily adjusted to meet varying conditions.

The screw type is the best known and may be used for any capacity of fuel required. To avoid outside variable controls to regulate the speed of the control, shutter vanes may be used to restrict the openings through which the coal travels in the screw.

The screw moves the fuel forward, where a slight quantity of air is thoroughly mixed with the coal. This jet of air should act as an ejector to prevent the bridging and arching of the fuel in the bin.

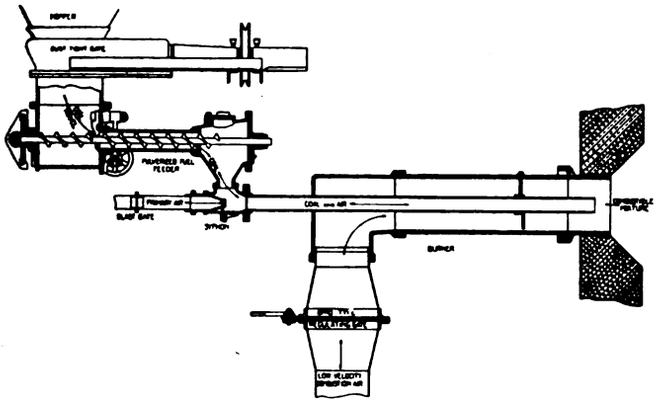
The syphon type is for lower capacities and the compressed air syphon type of controller is used. This method, which thoroughly mixes the air and coal before it reaches the burner, avoids pulsating or puffing of the flame, which is a particularly valuable attribute in furnaces having a restricted volume.

BURNERS

The burning of pulverized fuel depends to a large extent upon the nature of the flame desired and the work to be performed.

Central Duct Type of Burner

This type is extensively employed when a wide range of operation is desired or where the exact requirements are unknown and where flexibility and positive control are essential. This burner is so constructed that the combustion air completely



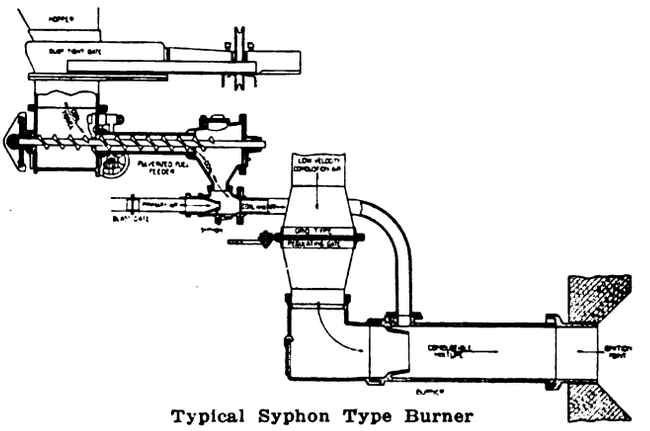
Typical Central Duct Burner

fills the burner at low velocity. The coal, having been previously mixed with a small quantity of air from the ejector, enters the center of the burner and commingles with the combustion air as it enters the furnace. Since the velocity of the combustion air is low, the mixture is, in effect, "breathed" into the furnace.

The burning of the fuel under these conditions of low velocity simplifies the furnace operation and enables the operator to keep furnace temperatures under close control.

Syphon Type Burner

The syphon type burner is used principally where temperatures desired are known and furnace conditions are uniform and where the temperatures desired need be varied within a relatively



Typical Syphon Type Burner

narrow range. This burner is so designed that the mixture of pulverized fuel and combustion air takes place before entering the furnace, thus insuring a very short flame if desired, and more rapid combustion, still having the marked advantage of entering the furnace at very low velocity.

Compiled from information furnished by the Hardinge Company, the Bonnot Company, and Heyl & Patterson Company.

INFORMATION FOR MANUFACTURERS

In order that engineers of manufacturing companies may make intelligent recommendations as to the equipment best suited to any particular requirements, it is necessary that the following information be furnished:

1. Capacity of pulverized fuel required, in tons per hour?
2. The character of fuel to be used, whether bituminous coal, anthracite coal, coke breeze, lignite, etc., and where obtained, with approximate ash content?
3. The maximum size that will be supplied to the pulverized plant?
4. What are specifications as to fineness?
5. What will be the percentage of moisture content as the fuel is supplied to the plant?
6. What grinding machine, if any, is now in use and what results are at present being obtained, including screen analysis of feed and product, capacity per hour and power to operate?
7. What form of power is to be supplied the pulverized fuel plant and how much power is available?
8. What system of burning the fuel is now installed?
9. For what character of burning will the fuel be utilized—kilns, reverberatory furnaces, open hearth furnaces, boilers, etc.?
10. Any other information which may be of interest in making out recommendations?

It is very important that the information outlined be as full and explicit as possible. Any recommendations as to capacity of plant based upon results obtained from installation already in operation and under practically similar conditions to those specified, with due allowance made for the difference in the process under consideration, should be given.

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TESTING FOR INSTALLATION OF ELECTRICAL PRECIPITATOR

In these times of growing interest in the subject Recovery of Waste Products, it often becomes necessary for smelting companies to make at least preliminary tests to determine the advisability of installing electrical precipitation plants. To a certain extent the same or similar tests must be employed for the proper consideration of any other type of apparatus for removing non-gaseous particles from furnace gases. The following outline is intended to include practically all of the information necessary for the approximate determination of the conditions which must be studied in figuring on a recovery plant. It is presented in the shape of Record Forms for:

I—Velocity and Volume Tests.
II—Sampling Tests.
III—Electrical Conditions.
IV—Recording of Performance under Different Conditions. Special Tests and Data.

I—Velocity and Volume Tests, etc.
- A—Pitot Tube Readings for
  - 1—Static Pressure
  - 2—Dynamic
- B—Anemometer
- C—Orifice
- D—Other Methods for Gas Velocity
- E—Temperature
  - 1—Thermometer
  - 2—Pyrometer
- F—Humidity, Dew Point, etc.
  - 1—Psychrometer
  - 2—Trial Methods, etc.

II—Sampling Tests
- A—Measurement of Gas Samples
  - 1—By Meter
  - 2—By Displacement
  - 3—By Pitot Tube
  - 4—Other Methods
  - 5—Corrections for Temperature, etc.
- B—Analysis of Gases
  - 1—For Acidity or other important constituents re Corrosion
  - 2—For CO, H_2, etc., re Explosibility
  - 3—Complete Analysis
- C—Measurement of Dust Contents
  - 1—Recovered by Precipitator
  - 2—Recovered by Extraction Thimble or Filter Paper, etc.
  - 3—Loss by Drying, etc.
- D—Analysis of Dust Contents
  - 1—For Values and Differentiation in proportion of these in different parts of the precipitator.
  - 2—Physical Classification according to size by (a) Screening and (b) Microscope.
  - 3—Classification according to Density and other physical characteristics, etc.

III—Electrical Conditions (For Electrical Precipitation Only)
- A—Primary Circuit
  - 1—Line Voltage
  - 2—Transformer Voltage
  - 3—Current
  - 4—Resistance
  - 5—Transformer Tap
  - 6—Kilowatts
  - 7—Power Factor
- B—Secondary Circuit
  - 1—Voltage
    - a—By Ratio
    - b—By "Sphere Gap"
    - c—By Position in Line
  - 2—Milliamperes
  - 3—Resistance
  - 4—Spill-over

IV—Special Tests and Data
- A—Effect of Changes in Plant Conditions
- B—Effect of Changes in Atmospheric Conditions
- C—Effect of Changes in Gas Velocity Thru Precipitator
- D—Effects of Changes in Temperature
- E—Effects of Humidification
- F—Effect of Changes in Electrical Circuit
  - 1—Use of Low Voltage Resistance
  - 2—Use of High Voltage Resistance
  - 3—Spill-over
  - 4—Inductance Coils
  - 5—Miscellaneous

The most common practice is for the smelting company either to have its own engineers make a preliminary test or to contract with the companies which install Recovery Plants to make a preliminary test. Upon the results of this preliminary test rests the decision of the smelting company as to whether a further investigation is advisable. If it is so considered the next move is to contract with the construction company to make exhaustive tests. These final tests furnish the company with data as to:

I—Values being lost.
II—Volume and physical and chemical conditions of gas and dust.
III—Size of installation, construction materials, power requirements and other data necessary for estimation of efficiency and cost of the proposed installation.

Further details will be furnished by any of the companies specializing in such work.

THERMOMETER SCALES

The following are the formulae for the conversion of degrees of one scale to those of another:

$$\frac{\text{Fahr.}^\circ - 32 \times 5}{9} = \text{Centigrade}^\circ$$

$$\frac{\text{Centigrade}^\circ \times 9}{5} + 32 = \text{Fahrenheit}^\circ$$

$$\frac{\text{Reaumur}^\circ \times 5}{4} = \text{Centigrade}^\circ$$

$$\frac{\text{Fahr.}^\circ - 32 \times 4}{5} = \text{Reaumur}^\circ$$

$$\frac{\text{Centigrade}^\circ \times 4}{5} = \text{Reaumur}^\circ$$

$$\frac{\text{Reaumur}^\circ \times 9}{5} + 32 = \text{Fahrenheit}^\circ$$

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MECHANICAL SAMPLING

Some automatic samplers take part of the stream all of the time, whereas others take all of the stream part of the time. But as the values in an ore are never evenly distributed across the stream, the former is not so efficient a method as the latter. R. H. Richards mentions seven essential features of a perfect mechanical sampler, which are:

1. It must take the whole stream of ore (wet or dry) part of the time.

2. The scoop that cuts out the sample must move completely across and out of the stream in one direction at each cut, for, if it enters from one side, and is then withdrawn on the same side without having completely crossed the stream, more ore will be taken from the side at which the scoop enters and leaves than from the other side. He also adds that although such a scoop may take part of the stream at a given time, it does take a true section across the stream and virtually takes the whole stream part of the time.

3. The scoop must move at a uniform rate, and the top of the scoop must, in all positions, be at right angles to the direction of the stream, in order to take equal proportions from all parts of the stream. This condition, he advises, is well obtained from a vertical stream and a horizontal scoop, in the case of a revolving scoop.

4. If the scoop that cuts out the sample revolves about an axis, two sides of the scoop should converge towards the axis in order to take equal proportions from all parts of the stream and the scoop may be adjustable to take larger or smaller proportions of the ore.

5. The interval of time between cuts should be constant.

6. The scoops must be deep and broad enough so that ore that has once got into them will not bound out again; and if the scoops have closed bottoms they must not be allowed to fill up so that some of the ore runs over, as this would produce a concentration of the heavy mineral, especially when the ore is carried in running water.

7. The machine should be simple and easily accessible for cleaning, to avoid danger of contaminating subsequent samples.

There are some samplers now used in mills and smelters that cover all of these points mentioned by Dr. Richards in his "Text Book on Ore Dressing." Such samplers are the Snyder, the Vezin and the Brunton.

ELECTROCHEMICAL EQUIVALENTS

Element	Valence	At. Wt.	Electrochemical Equivalent (1 amp. 1 sec.)
Al +.....	3	27.1	0.00009363
Ag +.....	1	107.88	0.0011183
Br —.....	1	79.92	0.00082845
Cd +.....	2	112.40	0.00058257
Ca +.....	2	40.0	0.00020732
Cl —.....	1	35.46	0.00036758
Co +.....	2	58.97	0.00030564
Cu +.....	2	63.57	0.00032948
Sn +.....	2	119.0	0.00061678
Sn +.....	4	119.0	0.00030839
Fe +.....	2	55.84	0.00028947
Fe +.....	3	55.84	0.00019267
F —.....	1	19.0	0.00019695
H +.....	1	1.008	0.000010449
I —.....	1	126.92	0.00131566
Hg +.....	2	200.6	0.00103661
Hg +.....	1	200.6	0.00207322
Ni +.....	2	58.68	0.00030414
Au +.....	3	197.2	0.00068139
O —.....	2	16.0	0.000082928
Pt +.....	4	195.2	0.00050584
Pt +.....	2	195.2	0.00101168
Pb +.....	2	207.1	0.00107340
K +.....	1	39.10	0.00040531
Na +.....	1	23.0	0.00023842
Zn +.....	2	65.37	0.00033881
Sb +.....	3	120.2	0.00041532
Mg +.....	2	24.32	0.00011567
Mn +.....	3	54.93	0.000189½
Si —.....	2	28.3	0.0001449
S —.....	2	32.07	0.0001656

Gore, Art of Elec. Separation of the Metals.

RESISTANCE OF ELECTROLYTES, COPPER REFINING

Strength Solution Per Cent.	Copper Sulph.		Iron Sulphate		Sulphuric Acid	
	Ohms per cc.	Ohms per cu. in.	Ohms per cc.	Ohms per cu. in.	Ohms per cc.	Ohms per cu. in.
2.5	92	37	..	..	....	....
5.0	53	21	..	..	4.8	1.9
7.5	..	..	65	26	....	....
10.0	31	12	..	..	2.5	1.0
15.0	24	10	34	14	1.8	0.7
17.5	22	9	..	..	....	....
20.0	..	..	..	..	1.5	0.6
25.0	..	..	..	..	1.4	0.56
30.0	..	..	25	10	1.37	0.55

J. W. Richards, Met. Calc.

SPECIMEN FORM SHEET FOR SCALES

(Information Desired by Manufacturers)

Style of Scale:
- Railroad Track .....
- Wagon .....
- Hopper .....
- Tipple .....
- Portable .....

Style of Beam:
- Single with Weights.....
- Double with Weights.....
- Triple with Weights.....
- Compound .....
- Recording .....

Distance from middle of edge of platform to beam rod .....

Capacity:
- Total—Dead and Live Load.....
- Dead Rail .....

Platform:
- Length .....
- Width .....

Framing:
- Timber .....
- Steel .....

Foundation:
- Stone .....
- Concrete .....

Character of soil where scale will be erected.....
.....

Number of feet of straight track where scale will be located.

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FLOW OF GAS IN PIPES

If d = Diameter of pipe in inches
Q = Quantity of gas in cu. ft. per hour
l = Length of pipe in yards
h = Pressure in inches of water
s = Specific gravity of gas, air being 1,
then

$$d = \sqrt[5]{\frac{Q^2sl}{(1350)^2h}}$$

$$h = \frac{Q^2sl}{(1350)^2d^5}$$

$$Q = 1350d^2\sqrt{\frac{dh}{sl}} = 1350\sqrt{\frac{d^5h}{sl}}$$

or Molesworth gives $Q = 1000\sqrt{\frac{d^5h}{sl}}$

while J. P. Gill gives $Q = 1291\sqrt{\frac{d^5h}{s(l+d)}}$

(Kent)

STACK DRAFT FORMULA

$$d=h\left(\frac{7.6}{t_a+460}-\frac{7.9}{t_g+460}\right)$$

d=draft in inches H_2O
h=height of stack in feet
t_a=temperature of air; t_g=temperature of gas.

Example:

For 100 ft. stack—
T_a= — 10° F.; T_g=300° F.

$$d=100\left(\frac{7.6}{450}-\frac{7.9}{760}\right)=100\ (.0169-.0104)$$

d=100 (.0065) = .65″ H_2O = total head.

—Bureau of Mines.

VAPOR TENSION OF VARIOUS METALS

Vapor Tension mm. of Mercury	Mercury at C.°	Lead at C.°	Silver at C.°	Gold at C.°	Cadmium at C.°	Zinc at C.°
0.0002	0	625	729	942	183	248
0.0005	10	658	766	987	200	267
0.0013	20	691	802	1031	216	286
0.0029	30	724	839	1075	233	305
0.0063	40	757	876	1120	250	324
0.013	50	790	913	1165	267	344
0.026	60	822	949	1209	283	363
0.050	70	855	986	1254	300	382
0.093	80	888	1023	1298	317	401
0.165	90	921	1059	1343	333	420
0.285	100	954	1096	1387	350	439
0.478	110	987	1133	1432	367	458
0.779	120	1020	1169	1476	383	477
1.24	130	1053	1206	1520	400	496
1.93	140	1086	1243	1565	417	516
2.93	150	1119	1280	1611	433	535
4.38	160	1151	1316	1654	450	554
6.41	170	1184	1353	1699	467	573
9.23	180	1217	1390	1743	483	592
14.84	190	1250	1427	1788	500	611
19.90	200	1283	1463	1832	517	630
26.25	210	1316	1500	1877	533	649
34.70	220	1349	1537	1921	550	668
45.35	230	1382	1574	1965	567	687
58.82	240	1415	1610	2010	584	706
75.75	250	1448	1647	2055	600	726
96.73	260	1480	1684	2099	617	745
123.0	270	1513	1720	2144	634	764
155.0	280	1546	1757	2188	650	783
195.0	290	1579	1794	2233	667	802
242.0	300	1612	1830	2277	684	821
300.0	310	1645	1867	2322	700	840
369.0	320	1678	1904	2366	717	859
451.0	330	1711	1941	2410	734	878
548.0	340	1744	1977	2455	750	897
663.0	350	1777	2014	2500	767	915
760.0	357	1800	2040	2530	780	930
Atmospheres Pressure						
2.1	400	1951	2197	2722	851	1012
4.25	450	2116	2380	2945	934	1107
8.0	500	2280	2564	3167	1018	1203
13.8	550	2445	2747	3390	1101	1298
22.3	600	2609	2931	3612	1185	1394
34.0	650	2774	3114	3835	1268	1489
50.0	700	2938	3298	4057	1352	1585

J. W. Richards.

COMPARISON OF VALUES FOR SURFACE TENSION OF METALS

Metal	S. W. Smith	Quincke	Siedentopf	Grunmach	
	Dynes per Centimeter	Dynes per Centimeter	Dynes per Centimeter	Dynes per Centimeter	Dynes per Centimeter
Selenium	.....	92.5	.....	.....	.....
Antimony	274.0	317.2	.....	.....	.....
Bismuth	346.0	464.9	429.5	.....	.....
Lead	424.5	535.9	509.5	.....	.....
				491.2	Stockle
Mercury	447.5	547.2	.....	450.0	435.6
				352.0	
Tin	480.0	681.2	612.4	359.0	.....
Aluminum	520.0	.....	.....	.....	.....
		967.0			
Zinc	707.5	1103.7	.....	.....	.....
Cadmium	.....	815.0	832.0	.....	.....
					Gradenwitz
Silver	858.0	782.4	.....	.....	751.0
					Heydweiller
Gold	1018.0	581.0	.....	.....	612.2
Copper	1178.0	.....	.....	.....	.....

S. W. Smith, Institute of Metals.

LATENT HEAT OF FUSION

Aluminum	100.0	Magnesium ...	58.0
Antimony	40.2	Mercury	2.83
Bismuth	12.64	Nickel	68.0
Bromine	16.18	Palladium	36.3
Cadmium	13.02	Platinum	27.18
Calcium	52.6	Phosphorus ...	5.13
Copper	43.3	Potassium	16.00
Cobalt	68.0	Selenium	13.0
Gold	16.3	Silicon	127.7
Ice	79.77	Silver	23.5
Iridium	26.1	Steel	20.0
Iron—cast white..	23.0	Sulphur	9.37
Iron—cast gray..	33.0	Tellurium	19.0
Iron—pure	69.0	Tin	14.0
Lead	5.37	Zinc	22.6

Hofman's Genl. Met.

THERMAL CONDUCTIVITY OF REFRACTORIES

	Firebrick	Quartzite (Ganister and Clay)	Silica (Ganister and Lime)	Magnesite (Dead Burned)
Silica	52.93	73.91	95.85	2.50
Alumina	42.69	22.87	0.88	0.50
Iron Oxide.....	1.98	1.48	0.79	7.00
Lime	0.33	0.29	1.80	2.75
Magnesia	0.38	0.31	0.14	86.50
Alkalis	1.55	1.20	0.39	.....
Loss on Ign...	.....	.....	.....	0.10
Density	1.91	1.91	1.56	2.46
K at 100° C....	0.0043	0.0051	0.0056	0.0343
K at 1000° C...	0.0086	0.0086	0.0108	0.0343

T. A. E. S., Boyd Dudley.

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Winslow Government Standard Scale Works, Inc.

Terre Haute, Indiana, U. S. A.

Manufacturers of

HEAVY CAPACITY SCALES

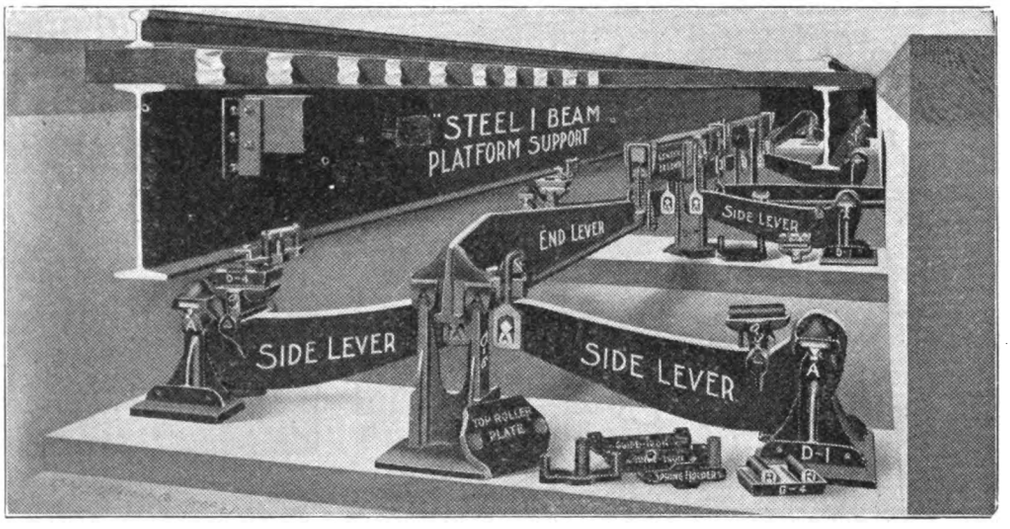
Products

We manufacture all sizes of heavy Scales, from 1 to 325 tons capacity; Mine Scales for tipple and underground service.

Construction

We use roller bearings to protect the knife edges from shock and scraping wear, thus insuring a life four times that of a scale suspended and wearing its knife edges by continual oscillation.

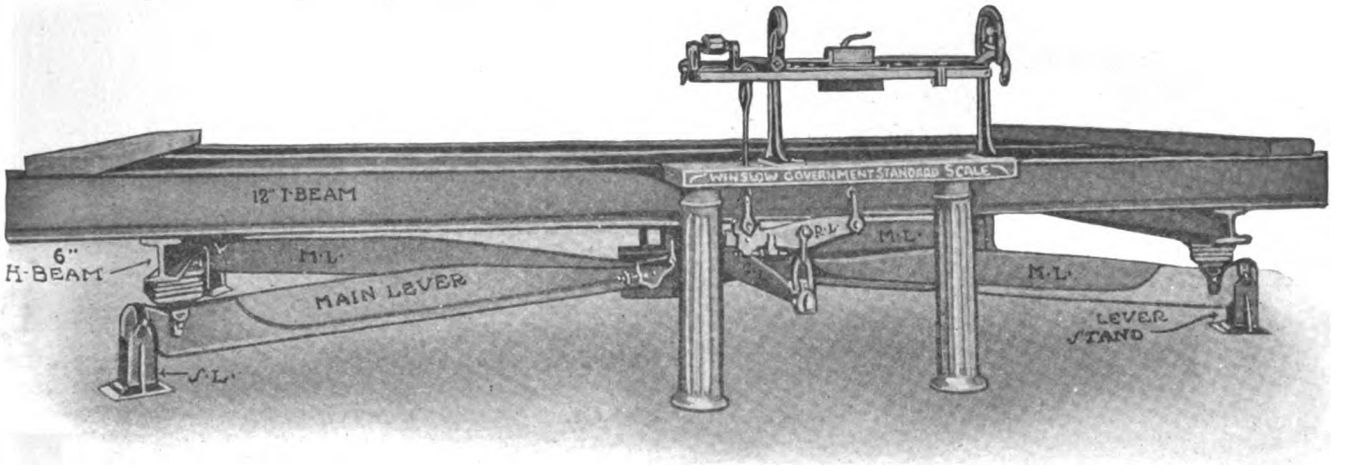
With the Winslow Scale no amount of shock can produce any slipping or scraping of the knife edge bearing on the surfaces with which they come into contact—an exclusive feature of our scale.



THIS IS THE BEST RAILROAD TRACK SCALE THAT BRAINS AND MONEY CAN PRODUCE.

Winslow Motor Truck Scale

The illustration below shows our latest improved "H Type" Motor Truck Scale. All main levers in this type of scales are of the same standard multiple. Each main lever sets on a stationary stand which rests on solid concrete foundation; this keeps the levers quiet and stops friction on knife edges. Ample motion of platform is given by use of rollers.



Winslow Motor Truck Scale

No main levers are held in suspension or permitted to swing. It is more simple, having less parts than any other motor truck scale on the market. There are only five levers under the scale. This makes it more durable and accurate and less liable to get out of order.

We Make a Specialty of Strong Motor Truck Scales.

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THE C. O. BARTLETT & SNOW CO.

Main Office and Works: CLEVELAND, OHIO, U. S. A.

Designers and Builders of

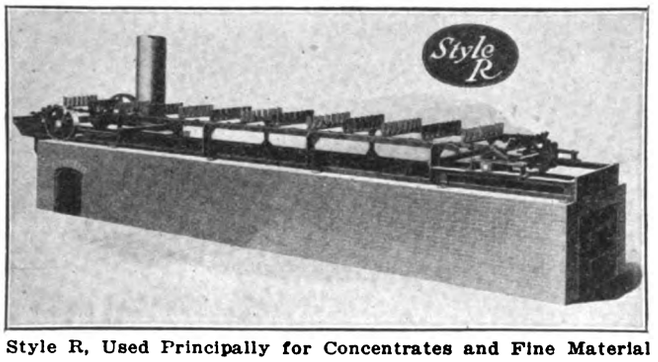
Material Handling and Processing Equipment

Products

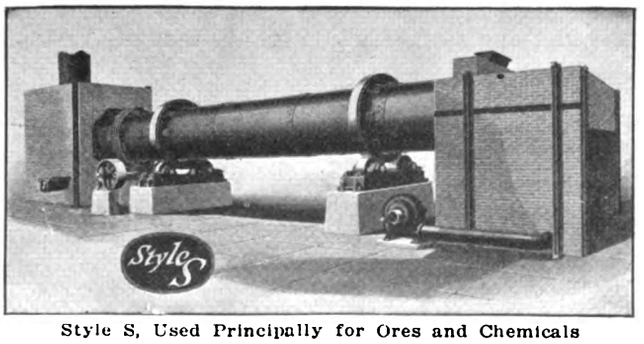
Conveying and Elevating Machinery; Skip Hoists; Dryers; Crushers; Pulverizers; Screens; Mixers; Feeders; Coolers; Bin Gates; Rotary Kilns; Car Hauls and Retarders; Coaling Stations; Mining Tipples; Sintering Plants.

Dryers for All Materials

Bartlett and Snow Dryers comprise thirteen different types, each one of which has been developed for drying a certain class of materials. If you will tell us the hourly tonnage, the amount of moisture in the wet material, and the amount of moisture (if any) that may be left in the product, we'll be glad to tell you which dryer will do your work best.



Style R, Used Principally for Concentrates and Fine Material

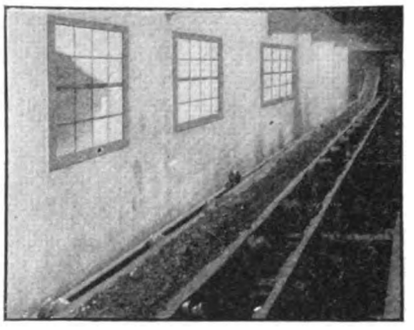


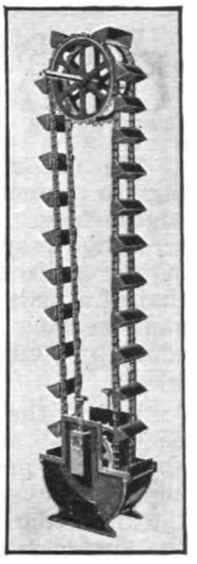
Style S, Used Principally for Ores and Chemicals

Style C, Used Principally for Coal

Conveying and Elevating Machinery

Bartlett and Snow Conveying and Elevating Machinery is built particularly for those conditions which are unusual or exacting. Bartlett and Snow engineers are always glad to offer their suggestions and give their co-operation on the design of conveying equipments.





Belt Conveyor and Bucket Elevator

Skip Hoists

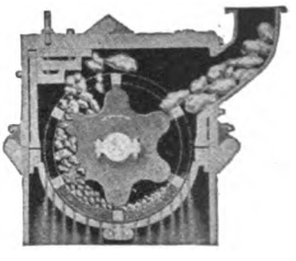
When conditions are severe, and bucket elevators may be subject to excessive wear or when lifts are high or capacities large, skip hoists will prove economical and dependable because of their ruggedness, simplicity, and low cost of operation.

Power plants, steel mills, chemical plants, mines, and sintering plants can use Skip Hoists for lifting coal, coke, ashes, limestone, flue dust, slag, ores and other gritty material.

Skip Hoist Handling Ore

The Cyclo Crusher-Pulverizer

Cyclo Crusher-Pulverizers are built for crushing materials of medium hardness. They take relatively little power, most of the crushing being done by impact of the material against the crusher blocks. Bulletin 42 fully describes this machine.



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RUGGLES - COLES ENGINEERING CO.

ESTABLISHED 1893

120 Broadway, NEW YORK CITY

Designers and Builders of

Ruggles-Coles Dryers

Products

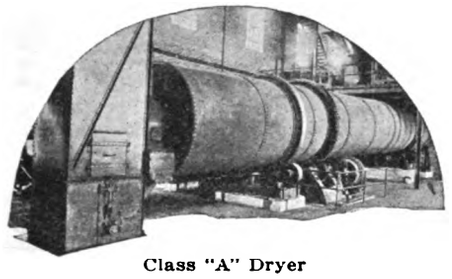
Ruggles-Coles Rotary and Paddle Dryers; double and single shell; eight standard types for drying by means of direct heat, indirect heat or steam.

Class "A" Dryer

This is a patented double shell, direct heat dryer especially adapted for materials which can be dried in large quantities, viz:

Coal	Rock
Coke	Sand
Ores	Stone
Clays	Concentrates, etc.

With this type of dryer, the maximum temperature to which the material can be heated is 400° F.,



Class "A" Dryer

though the machine may be so operated that the material will not be heated to over 220° F.

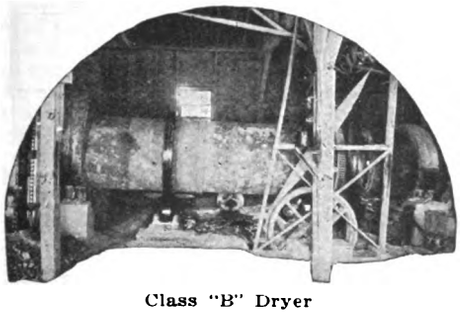
Our Class "A" Dryer is built in nine standard sizes.

Class "B" Dryer

Our Class "B" Dryer is a patented double shell, indirect heat dryer,especially designed for drying

China Clays	Whiting
Talc Rock	Kaolin

and those materials which may be dried at a fairly high temperature but must not come in contact with



Class "B" Dryer

the products of combustion due to possible injury or contamination.

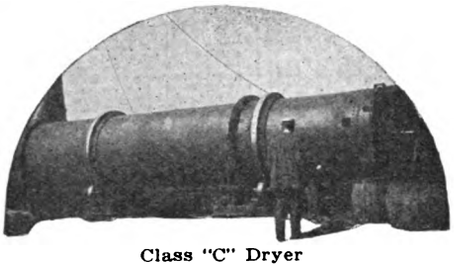
This dryer is made in three standard sizes.

Class "C" Dryer

A rotary steam dryer for materials which must be dried at a low temperature to prevent injury to the material, viz:

Brewer's Grains	Starch Feed
Cotton Seed	Tobacco Stems

Corn Germs, etc.



Class "C" Dryer

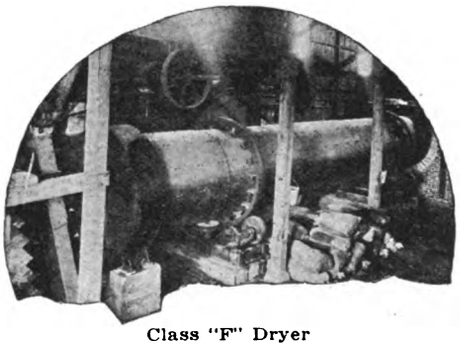
Either live steam or exhaust steam may be used to greatest advantage with our Class "C" Dryer, which is made in four standard sizes.

Class "D" and "E" Dryers

These are paddle dryers, built in special sizes for direct heat, indirect heat or steam—depending upon the material to be dried.

Class "F" Dryer

This is a single shell, direct heat dryer of heavy and substantial design for use on those materials



Class "F" Dryer

and in those places where first costs are the main consideration.

Our Class "F" Dryer is built in seven standard sizes.

General

For over a period of 28 years, the Ruggles-Coles Engineering Company have specialized in drying problems and drying equipment. Our dryers possess a high reputation for rugged construction; continuity of operation; low maintenance and operating costs; greatest capacity and thorough drying.

We suggest that inquiries regarding any of our eight types of dryers be accompanied by specific information concerning the material to be dried and conditions of operation. Full details will be gladly submitted.

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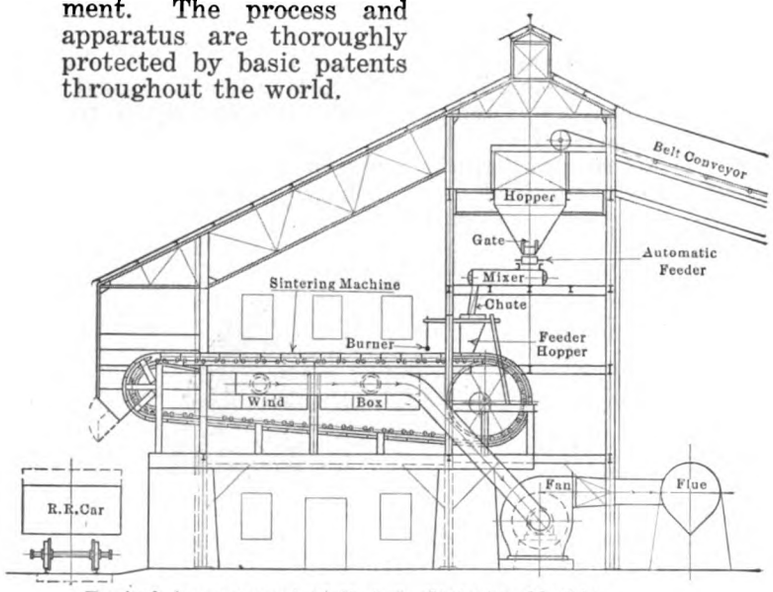
DWIGHT & LLOYD SINTERING CO., Inc.

29 Broadway, NEW YORK CITY

Cable Address: Sinterer, N. Y.

Sintering and Agglomerating Apparatus

Sintering fine ores and concentrates by the D & L process and apparatus is standard practice the world over, for the preparation of ores and concentrates for blast furnace or other subsequent treatment. The process and apparatus are thoroughly protected by basic patents throughout the world.



Typical Arrangement of D. & L. Sintering Machine (Horizontal Type)

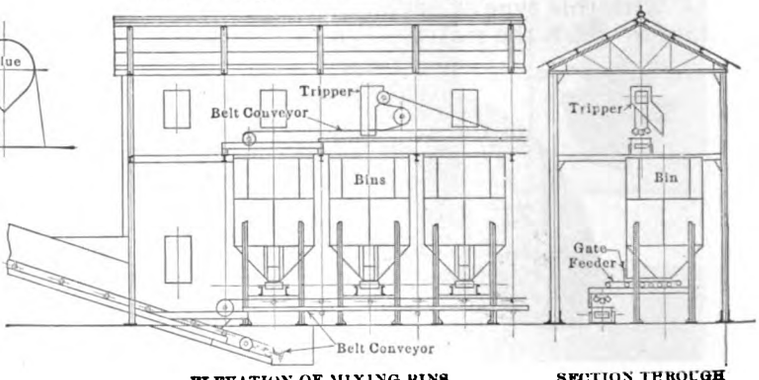
In the Non-Ferrous Field

Are at present being treated oxidized, partially oxidized and base ores, calcines, flue-dust, fumes, by-products, and other special materials, phosphate rock and other earthy minerals.

In the Ferrous Field

Are being treated hematite and magnetite ores and concentrates, flue-dust, pyrites cinder, blue-billy, mill scale and other special products.

We specialize in the solution of roasting and sintering problems in both ferrous and non-ferrous metallurgy—iron, lead, copper, zinc, tin, precious metals, etc.

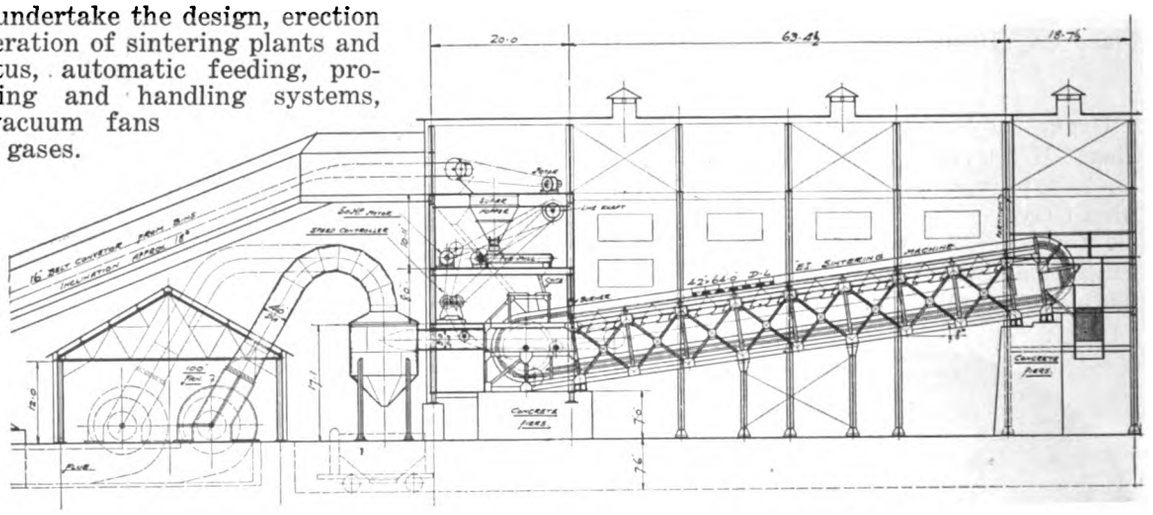


ELEVATION OF MIXING BINS

SECTION THROUGH BINS AND FEEDERS

We have a TESTING PLANT equipped with roasting and sintering apparatus for the solution of such problems on a working scale, and our engineering staff, composed of trained metallurgists, chemists and mechanical engineers experienced in this field are at your service.

We undertake the design, erection and operation of sintering plants and apparatus, automatic feeding, proportioning and handling systems, high vacuum fans for hot gases.



Large Type (Inclined) Machine, Built for Capacities Up to 800 Tons Per Day

ALLIED OR ASSOCIATED COMPANIES

Dwight & Lloyd Metallurgical Company

29 Broadway, New York City

Consulting Metallurgists and owners of the Dwight & Lloyd patents for process and apparatus in countries other than North America.

American Ore Reclamation Company

71 Broadway, New York City

Sole licensee for the exploitation of the Dwight & Lloyd system and apparatus for ferrous metallurgy in North America.

Sintering Machinery Corp.

Netcong, New Jersey

Licensed manufacturers of all Dwight & Lloyd apparatus, also special fans, stacks and furnaces.

Pulverized coal burners for ignition furnaces. Mixers, and pug mills, and other accessories. Sheet and structural work, and special smelter fabrication in general.

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HERRESHOFF FURNACE DEPT.

of the
GENERAL CHEMICAL COMPANY
40 Rector Street
NEW YORK, N. Y.

of the
PACIFIC FOUNDRY COMPANY
18th and Harrison Streets
SAN FRANCISCO, CAL.

Products

The New Herreshoff Furnace

for Roasting Ores { (a) for the Manufacture of Acids. (b) for Metallurgical Purposes.

for Calcining.

for Drying.

In the roasting of ore the problem is to so manage the operation that as high a temperature as possible may be used at each step of the roasting, without at any time reaching conditions that cause fusion. By means of patented temperature control features incorporated in the **New Herreshoff Furnace** these temperature requirements, so essential to successful operation, can be controlled and maintained to the highest efficiency.

In the **Calcination** of materials where specific temperatures must be maintained for a given period of time the **New Herreshoff Furnace** has demonstrated its efficiency on account of its close temperature regulation and large hearth area on which the specially designed rabbles effectively expose each particle of material to the necessary temperature. The economy of space due to the compact construction of the furnace and the consequent economy of fuel are additional factors in making this apparatus so effective as a **Calciner.**

In the **Drying** of materials the **New Herreshoff Furnace** has been successfully adapted to specific problems.

Air is used for cooling the **New Herreshoff Furnace** and its function is fourfold.

1st—It keeps the cast iron shaft and arms at a temperature where the metal possesses its maximum strength.

2nd—It serves to regulate the temperature of the roasting process itself: for, since it is a forced draught, it can be exactly controlled, and so regulated as to maintain a proper temperature inside the furnace.

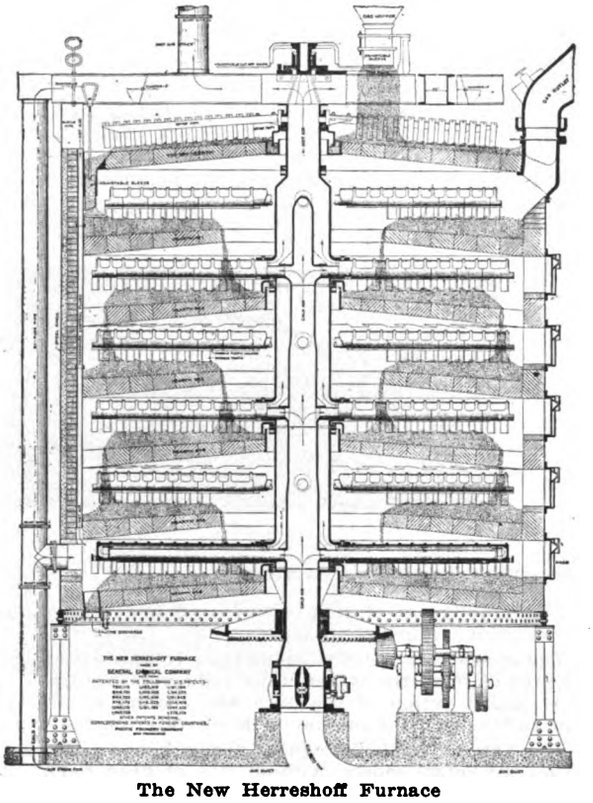
3rd—It permits the installation of temperature control flues, which absorb any excessive localized heat and transmit it to the cooler zones of the furnace.

4th—It permits the utilization of waste heat for combustion, either with or without the use of extraneous fuel.

Construction and Operation

The **New Herreshoff Furnace** has a cylindrical steel shell placed vertically, lined with red or fire brick, and in this shell brick hearths are placed horizontally one above the other. Utilization of the top (or roof) of the first hearth has been made so that it acts as a pre-heater. The ore drops from the hopper to this preheating hearth and is rabbled across it, thereby freeing itself of a great portion of its moisture content before entering the furnace. Passing down through the center of these hearths is a double vertical hollow shaft. Attached to this shaft between the shelves are two removable arms carrying replaceable rabbles, or teeth. On the first hearth the rabbles are placed at such an angle that the revolving arms plow and turn the roasting ore over in a regular way, making it travel from the center of the hearth outward. From there it discharges through proper openings onto the hearth below, where the teeth are placed at an opposite angle to the one above so as to turn and plow the ore from the outside toward the center of the furnace, where it again drops to the hearth below, as shown in the illustration. This operation is repeated until the ore finally discharges through an opening placed at the outer edge of the bottom hearth. The rabble teeth are so arranged, in regard to their pitch and progression, that the movable ore body maintains a regular form of furrows, from the center to the circumference on all hearths.

The life of the central shaft and arms, as well as the teeth, is prolonged by internal cooling. This cooling is accomplished by air, which is forced into the bottom of the shaft, as shown in the illustration, and then delivered through the central shaft, from which it passes in multiple at once into all the arms. After cooling the arms and shaft the air is conveyed to the annular bustle pipe surmounting the vertical temperature flues, through which it passes to the bottom shelf, fulfilling a twofold purpose: first, the equalization of temperatures on the hearths; second, additional oxidation for combustion by the admixture of preheated air.



The New Herreshoff Furnace

Sizes

The **Herreshoff Furnace** is built in diameters of 11′-7½″, 15′-9¾″, 18′-0″, 19′-6″, 21′-6″, with from 5 to 9 hearths as required. In addition a laboratory size has been developed for experimental purposes. This has a diameter of 4′-6″ with 6 to 10 hearths as required.

Uses

There were in 1921 over 2200 of various sizes of the **Herreshoff Furnace** in practical and economical operation in the following fields:

1—Roasting pyrites for manufacture of sulphuric acid.
2—Roasting pyrites for manufacture of sulphite pulp.
3—Roasting pyrrhotite for manufacture of sulphuric acid.
4—Roasting of mixed sulphides for magnetic separation.
5—Preliminary roasting of simple or complex sulphides for metallurgical work.
6—Calcination of materials where specific temperatures must be maintained for a given period of time.
7—Drying.

Inquiries

Each inquiry is treated as a special engineering problem.

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THE STEARNS-ROGER MFG. CO.

DENVER, COLORADO

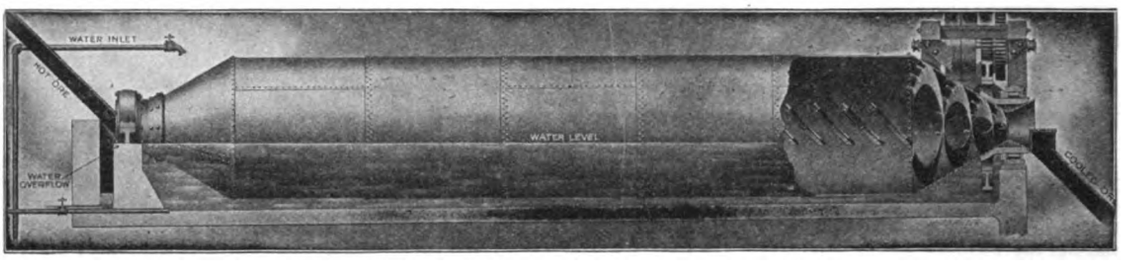
Engineers, Contractors and Manufacturers

Products

For forty years, The Stearns Roger Manufacturing Company has been engaged in the design and construction of mining equipment, as well as complete mining, metallurgical and power plants.

The new works, into which it will shortly move, will be the largest, most modern and best equipped of the kind west of the Mississippi River and will afford even better facilities for the economical production of the heaviest types of foundry, machine shop or boiler shop products, either standard or special.

Standard Stearns-Roger Machines include the following: Ball Mills, Crushers, Cages and Skips, Coal Crushers, Concentrating Tables, Cyanide Machinery, Coolers, Dryers, Elevators, Filter Presses, Flotation Machines, Gold Dredges, Kettles and Slag Pots, Lime Kilns, Magnetic Separators, Rolls, Samplers, Tanks, Trommels and Transmission Machinery.



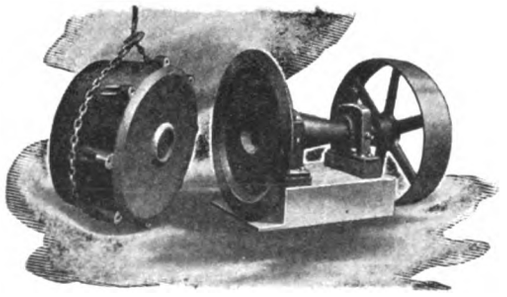
The Baker Cooler

The Baker Cooler (Patented)

The problem of efficiently and economically cooling and conveying red hot ore and other materials is solved by the Baker Cooler illustrated above.

The cylinder is partly submerged in the water bath contained in a concrete tank surrounding it and, by displacement, is FLOATED on the water, thus reducing friction to a minimum and economizing power. The shell is protected by the water jacket action of the bath and cooling is effected partly by absorption of heat in the water but chiefly through evaporation from the constant film of water on the exposed surface.

The hot material, introduced through one cone-shaped end, is advanced by plows and raised and discharged at the other end by the spiral shown, without loss of head room. The hourly heat dissipation is from 5½ to 6½ B.T.U.'s per square foot per degree difference between inside and outside temperatures. Standard diameter is 5 feet. Lengths vary from 10 to 50 feet according to desired capacity. Feed temperatures up to 1800 degrees Fahr. Capacities up to 15 tons per hour. Less than 3 H. P. and 20 gallons water per minute required when cooler is under 30 feet in length. Operation is dustless and upkeep expense negligible. Special equipment can be provided if unusually low final temperatures are required.



Ball Mill or Granulator

The Overhung Ball Mill (Patented)

The Stearns-Roger Overhung Ball Mills or Granulators are simple, sturdy, economical and fool-proof.

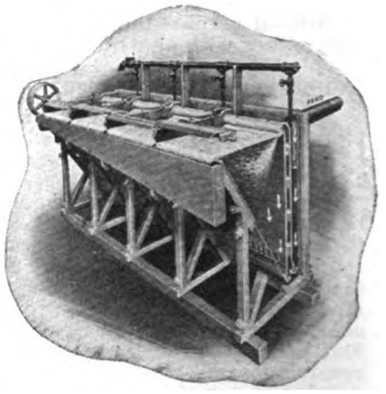
Singly, in pairs or in tandem, and operated either wet or dry, they are doing the entire grinding in small mills and experimental or testing plants. They are unexcelled as middling grinders.

The drum—an inexpensive rough casting of special hard iron, quickly and cheaply replaced—is the only wearing part. No gears—bearings reversible, adjustable and self-aligning.

Built with or without grates and radial lifters and in two sizes: 3'x18" requiring 5 to 7 H. P., 3'8"x6'3" floor space, and weighing 3,500 pounds; 4'x2' size requiring 9 to 12 H. P., 5'x7' floor space, and weighing 6,000 pounds. Capacity up to one ton per hour or equal to that of any other ball mill of similar size.

The Brown Flotation Machine (Patented)

The Brown Flotation machine is unusually simple in construction and operation. It has only one moving part—the froth paddle. No porous blanket to choke, no valves, no sensitive pulp levels. It is recommended for general or selective flotation, for clean-up purposes and as a scavenger or guard—where its low initial and operating cost, together with the completeness of recovery and high grade of froth produced, make its installation almost invariably highly profitable.



Brown Flotation Machine

It can be shut down without draining—starts immediately the air is turned on, requires few adjustments and operates steadily.

Sizes Made	Floor Space for 4 Cells	Air Requirements		Capacity Tons per 24 Hours
		Cu. Ft.	Lbs. Pressure	
4'	4' 2"x 9'6"	33	2½	50
5'	4'10"x12'6"	44	3	100
6'	5' 5"x12'6"	55	4	200

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AMERICAN ABRASIVE METALS CO.

50 Church Street, NEW YORK

Makers of

"FERALUN" Rabble Blades and Pug Mill Paddles

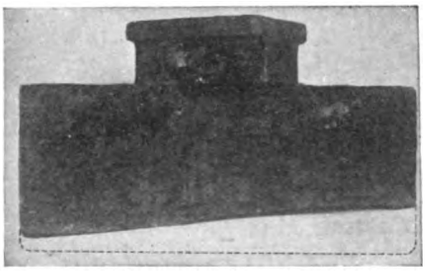
Patented February 17, 1920, and May 25, 1920

Products

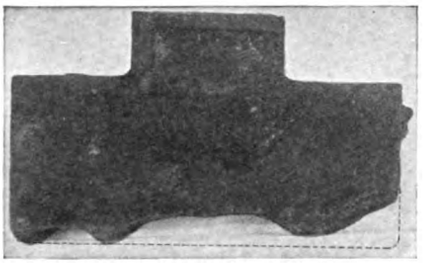
Rabble Blades; Pug Mill Paddles; Anti-Slip Treads and Floor Plates; Brake Shoes.

"Feralun" Rabble Blades

In the operation of roasting furnaces the rabble blades are the source of a great deal of trouble and expense. Blades are ordinarily made of cast iron, and these soon wear out, due to the action of heat and the abrasive material being handled. Wear is most rapid on the bottom and front edge, causing the hearth to build up. Material must be kept moving or it soon forms a clinker and interferes with operation of the furnace. When clinkering occurs the furnace must be shut down and allowed to cool off enough to permit workmen to enter, plow or bar up the hearth, remove the old blades and insert new ones. All this together with the cost of new blades, constitutes a large item of expense.



Cast Iron—In Service 22 Hours



"Feralun"—In Service 120 Hours

"Feralun" and Cast Iron Blades Tested Simultaneously in the Same Service Lasted as Shown

"Feralun" Rabble Blades do not differ materially in form or appearance from ordinary cast iron blades. But along the edge where the greatest wear comes, chunks of abrasive grit, excelled only in hardness by the diamond, are embedded in the metal. This grit is embedded in a special iron composition which gives a rabble having a long life and requiring less frequent renewals than blades of cast iron. Cut shows distribution of grit on working edges of rabble.

"Feralun" Rabble Blade Showing Grit

Advantages of "Feralun" Rabble Blades

Lasting five to ten times as long as cast iron and selling for only two or three times as much, blades of "Feralun" cut maintenance costs and increase production.

Lost time of production is greatly lessened, the furnace is enabled to work at capacity many more days per year, and only one-fifth to one-tenth as many blades must be bought for renewals. One company got 20 days' service from cast iron blades and 120 days from "Feralun." After adopting "Feralun" they gained in active operation of their furnaces nine days in four months, which is at the rate of 27 days saved per year. Being cast, the "Feralun" Blades are obtainable in any design to fit the various types of holders used in Wedge, McDougall and Herreschoff Furnaces.

"Feralun" Pug Mill Paddles

In Pug Mills, the application of "Feralun" Paddle Blades has all the advantages of "Feralun" Rabble Blades in Roasting Furnaces. For paddles and blades in Pug Mills used in preparing materials for sintering, brickmaking, etc., "Feralun" is obtainable in shapes to meet customer's requirements.

In a mill mixing materials for a sintering plant, iron paddles lasted ten days, while "Feralun" paddles remained in use three months and still were giving good service.

"Feralun" Anti-Slip Treads

Anti-Slip Treads, made of "Feralun," reduce the danger of accidents from slipping around furnaces, boiler rooms and on stairs. Mud, oil or soapy water does not make them slippery. Treads or plates of "Feralun" do not deteriorate though corrosion like those having a steel base.

Used For

Shipping Platforms and Runways, Boiler and Machinery Room Floor Plates, Trench and Gutter Covers and Drainage Gratings, Fire Door Saddles and Fire Escape Steps, Coal and Manhole and Hoist Covers, Engine Steps and Running Boards, Crosses and Strips for Inclines, Car Steps and Platforms, Stair Treads and Landings, Elevator and Door Thresholds.

"Feralun" Brake Shoe

Is not only used to keep mine motor wheels true —IT IS A SERVICE SHOE AS WELL. It is put on old or new wheels, keeping the new wheels from getting false flanges and removing false flanges if put on old wheels.

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Allis-Chalmers Manufacturing Company

MILWAUKEE, WISCONSIN

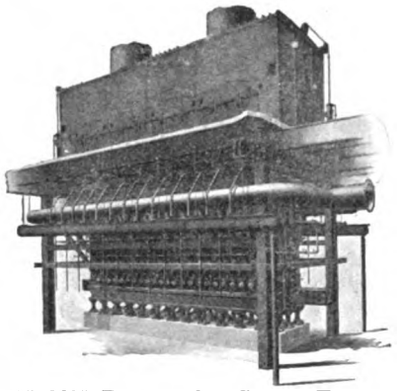
For Branch Offices and Other Products, See Page 168

Smelting and Refining Equipment

Products

Blast and Reverberatory Smelting Furnaces; Forehearths; Settlers; Slag Pots; Slag Cars; Matte and Slag Ladles; Ladle Bails; McDougall Multiple Hearth Roasting Furnaces; Copper Converters; Walker Circular Casting Machines; Straight Line Casting Machines, etc., etc.

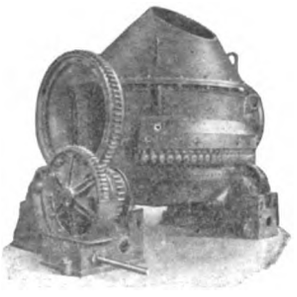
We specialize in the manufacture of equipment for mining and smelting and our equipment is always the most modern.



50"x360" Rectangular Copper Furnace

Blast Furnaces

The Allis-Chalmers Manufacturing Company are equipped to manufacture blast furnaces for smelting copper or lead, for great or small capacities, according to the requirements. These furnaces are made in various sizes, either round or rectangular. Our Engineering Department is always ready to advise in the selection of the furnace best suited to the conditions.

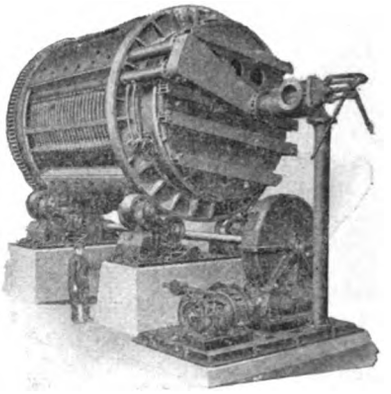


Great Falls Type Copper Converter

Copper Converters

The illustrations show the vertical and horizontal copper converters. The "Great Falls" type is made in sizes up to 20 feet in diameter, and the horizontal or "Peirce-Smith" type, is made in sizes 10 to 13 feet in diameter and up to 30 feet in length. These converters are made for receiving a basic lining. Allis-Chalmers Manufacturing Company build converters in the most modern and up-to-date designs; to be tilted by electric power.

The above sizes are for use in large smelting plants. We also manufacture copper converters for plants of smaller capacity, including a "hand-tilted" type for remote districts.



Peirce-Smith Copper Converter

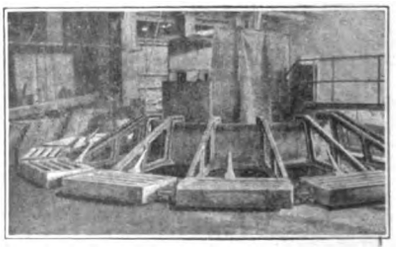
Casting Machines

Where the quantity of copper produced is large and it is desired to keep the non-productive time of each converter down to a minimum, the blister copper is carried in ladles by a crane to a casting machine. This replaces the slow method of pouring or casting all the copper produced from the converter spout.

The Allis-Chalmers Manufacturing Company manufacture both the circular and "straight line" types of casting machines.

The following illustrations show both types.

Straight Line Copper Casting Machine



Walker Casting Machine

When in the market for Mining and Smelting Equipment send for our bulletins.

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Worthington Pump and Machinery Corporation

Executive Offices
115 Broadway, NEW YORK

For List of Works and Offices, See Page 493

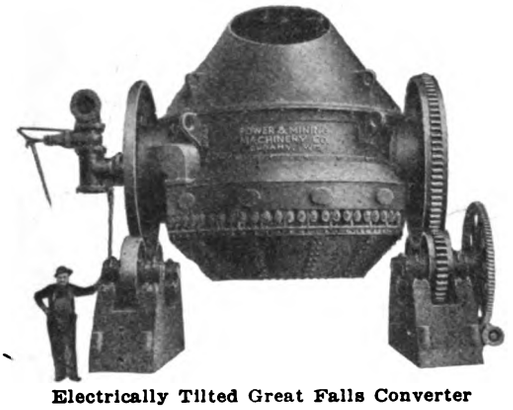
Smelting and Refining Equipment

Products

Copper Converters; Slag Cars; Matte and Slag Ladles; Ladle Bails; Pots; Casting Machines; Smelting Furnaces; Reverberatory Furnaces; Blast Furnaces. For other products see Pages 165, 176, 463, 493 and 626.

Copper Converters

The latest type of electrically tilted Copper Converter is shown in the illustration. This converter is of the vertical type, one of its points of superiority being the longer life of the lining. It is made in sizes up to 12 feet in diameter. The shell is of heavy steel plates and cast iron sections riveted together. They are supported on rollers and may be tilted by electric or hydraulic power, as desired.



Electrically Tilted Great Falls Converter

The horizontal converter is shown in the illustration in the second column. This is similar to the vertical type, except that it is hydraulically tilted, the tilting device consisting of a rack actuated by a hydraulic cylinder and engaging a gear attached to the flexible coupling shaft.

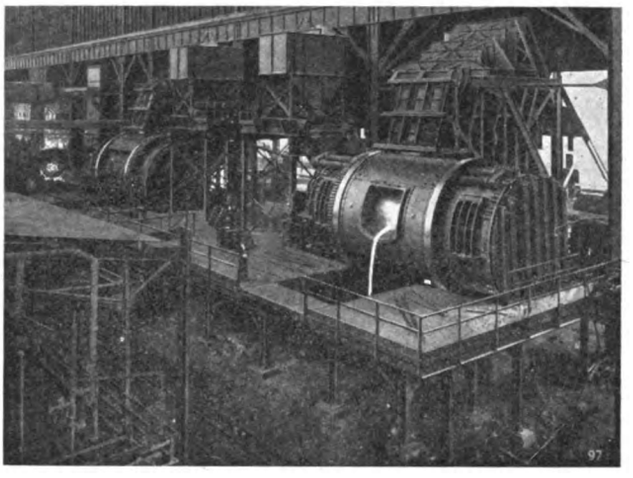
The gear frame is made of heavy box-section, strongly ribbed and provided with a large base. The upper end of the frame carries two bearings for gear and flexible coupling shaft. Gear frame is provided with a removable and adjustable guide, finished to receive the cast iron rack. The hydraulic cylinder is made of semi-steel and when so desired can be provided with a brass lining. It is securely attached to the bottom of the gear stand.

Upper cylinder head is accessible from the floor to permit repairing the piston and gland without entering the pit, and without disturbing connection between cylinder and gear stand.

Worthington furnishes four-way balanced hydraulic operating valves for these converters, which may be placed in any convenient location.

Converter Accessories

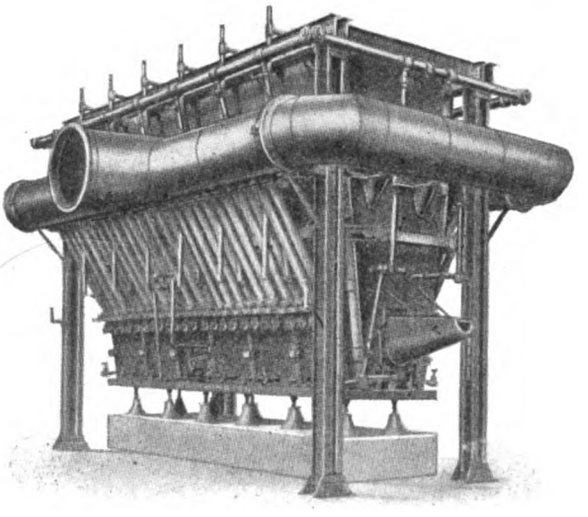
Worthington also manufactures converter accessories, including Slag Cars, Matte and Slag Ladles, Ladle Bails, Pots, Straight Line Casting Machines, etc.



Horizontal Converter, Hydraulically Tilted

Blast Furnaces

Worthington can furnish Blast Furnaces for either silver lead or copper, in either the round or rectangular form. These furnaces are made in several sizes, and the Engineering Department is at your service to assist and advise you in the selection of the proper equipment.



Rectangular Water-Jacketed Copper Blast Furnace

Water Jackets

These can be furnished separate from the complete furnace.

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E. H. STROUD & COMPANY

ESTABLISHED 1896

928, 930, 932 and 934 Fullerton Avenue

CHICAGO, ILLINOIS

Engineers and Manufacturers of Machinery for the Reduction of All Sorts of Dry Grindable Materials, Animal, Chemical, Mineral and Vegetable, and Some that Carry 6% to 8% of Moisture: also of Dust Collecting Devices and Powdered Coal Burning Equipment

PRODUCTS

Crushing, Granulating, Disintegrating, Pulverizing and Shredding Machinery; Dust Collectors; Air Vent Chambers; Stokers and Combustion Chambers for burning Powdered Coal, for Locomotives, Steamships, Stationary Boilers, Stills, Retorts, Kilns, Metallurgical Furnaces, etc.

PIONEERS in the art of pulverizing and stoking and burning Powdered Coal, under Boilers and some other Heating Units.

Stroud Powdered Coal Stoker and Burner

Receives the Powdered Coal, draws its own supply of Air from the atmosphere, measures the coal and the air as used, mixes them thoroughly, delivers the mixture to the furnace (where it ignites at once) and enables the operator to have complete control of furnace temperatures, and to make records from which to duplicate his results at will. We build also a Stoker for Locomotives.

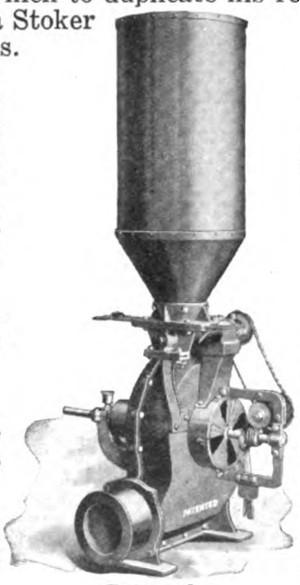
Illustration is of our Left-Hand Stoker. We build Right-Hand as well.

Stoker can also be built for either upward or downward delivery.

Slide——→ to start and stop flow of coal.

Pulley——→ or Electric Motor or Steam Turbine, as desired.

Outlet——→ of Fuel Mixture.



←——The Coal Tank can be of other size and shape, or can be a metal barrel if preferred.

←——Sprockets, Chain, Worm and Gear, which drive the Conveyor from spindle of fan, and automatically govern the supply of coal.

←——Air Inlet and Controller.

All persons are warned that the ideas embodied in the "Stroud Powdered Coal Stoker and Burner" have been well covered by fundamental patents.

Patented

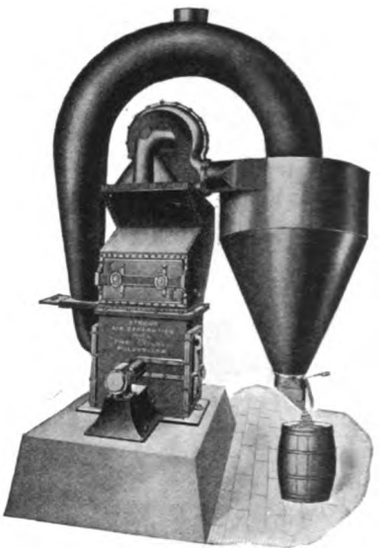
Sizes and Capacities from 15 lbs. to 5000 lbs. of coal per hour per stoker with all the air needed for combustion. **Write for Bulletins "A" and No. 107.**

Crushing and Granulating Roller Mills

With either pointed or chisel-shaped cutters, or fluted rollers, one pair, two pairs, or three pairs of rolls high, per mill. **Ask for Bulletin No. 200.**

Stroud Air Separation Pulverizers

Our illustration shows a Product Collector attached to the Pulverizer. We also build the all-metal 100% efficient Stroud Dust Collector.



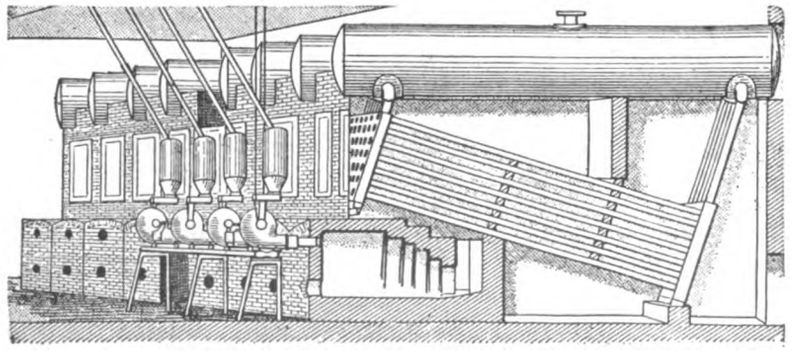
These mills give a finished product direct which, without subsequent sieving, is so uniformly fine that 95% or 98% or all of it, as wanted, will, if tested when dry, pass through a horizontal brass wire cloth testing sieve of the desired mesh, which can be any mesh from, say, 40 x 40, down to the most impalpable powders, far finer than a 200 x 200 mesh. They are without exception the most efficient Pulverizers made. Dustless in operation. Difficult to clog. Easy to clean. A cool Pulverizer for chemicals. So automatic in feeding and operation that one man can attend half a dozen mills. Cost of milling very low. **Ask for Bulletin No. 101-A.**

Throw-Out-Box-End-Door

For cleansing materials from imperfect and foreign matter during process of pulverization. **Ask for Bulletin No. 101-B.**

Stroud Screen Separation Crushing and Grinding and Shredding Mills

Ask for Bulletin No. 102-B.



Rough Sketch of a Typical Stroud Powdered Coal Installation

We have purposely made an incorrect drawing of the Furnace and some other details because we do not wish to advertise or give away gratis information which has cost us considerable time and money and effort. The Stokers can be placed overhead instead of in front of Furnace.

Our installation is as simple as that shown, and gives entire satisfaction.

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WIEDERHOLDT CONSTRUCTION CO.

30 Church Street
NEW YORK

428 Olive Street
ST. LOUIS

Wiederholdt System Smelter Chimneys

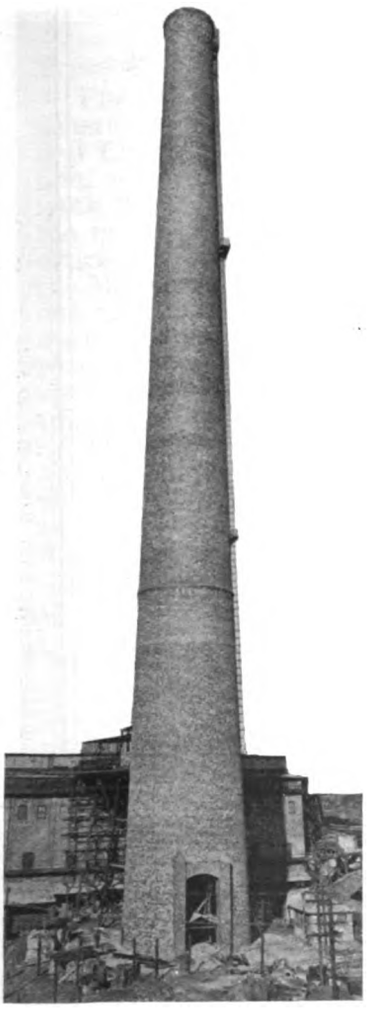
Products

Chimneys, Acid Towers, Cooling Towers, Storage Bins, Tanks, Etc.

Wiederholdt System Smelter Chimneys

Permanent—Acid-Proof—Light Weight—Economical.

A combination of the three most durable materials known—HARD BURNED TILE—HIGH CARBON STEEL—PORTLAND CEMENT CONCRETE.

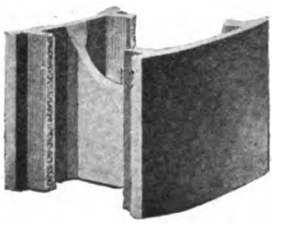


450' x 24' Chimney at United States Smelting, Refining & Mining Co., Midvale, Utah

Durability

Due to the character of the materials used and the careful construction of Wiederholdt System Smelter Chimneys, they are heat and acid resisting, light in weight and permanent.

The first chimney built—16 years ago—is still in use and in perfect condition.



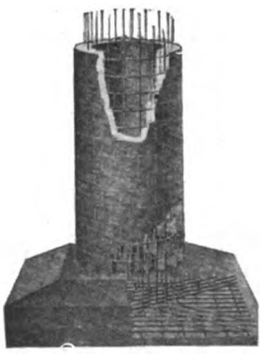
The Tile

Engineering Service

We maintain a staff of engineers which is at your disposal in solving your problems pertaining to Chimneys, Acid Towers, Cooling Towers, Storage Bins, Tanks, etc. This service is free and does not obligate you in any way.

Send us your specifications.

OUR NEW BOOKLET IS JUST OFF THE PRESS. A CARD WILL START IT TO YOU.



The Method of Construction

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SECTION XX

Flotation and Chemicals

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

American Cyanamid Co.
Cleveland-Cliffs Iron Co.
Connersville Blower Co.
General Naval Stores Co.
Groch Centrifugal Flotation Co.
Hercules Powder Co.
Roessler & Hasslacher Chemical Co., The
Southwestern Engineering Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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THE FLOTATION PROCESS*

While a comparatively new method of treatment, the flotation process now leads all others in tonnage of non-ferrous ores treated. This indicates the success of the process better than any other statement that could be made. Many mills are now being built as straight flotation plants, while others depend upon flotation for the principal recovery of values, with tables as accessories only. In a few cases even amalgamation and cyanidation have been superseded by flotation treatment. A large percentage, however, of mills using the process have added a flotation plant to their present equipment for the purpose of treating slimes and reground middlings.

In a few districts operators are still skeptical or mildly antagonistic toward the process, though in such sections there are usually a few progressive mill men who use flotation successfully. Unless a better process appears in the future, it is likely that flotation will become nearly universal in mills treating base ores, and common in mills treating ores of the precious metals. As an example of possible development, the Premier Mill in British Columbia is reported to be floating minerals in cyanide solution. In other cases the values are recovered by flotation and the concentrate cyanided.

Types of Flotation Processes

Flotation processes may be divided into three general types. First, bulk oil flotation, as with the first Elmore process. Second, surface tension flotation, as with the Macquisten tube method. Third, froth flotation (so-called "oil flotation"), which is the method in common use and described in this article. The Elmore process is no longer used, and the Macquisten tube has been discarded, except for one mill, that of the Morning Mine in the Coeur d'Alenes, Idaho, which still uses the process to some extent. It gives satisfactory results on the coarser sizes of feed, but will not handle slimes successfully.

The characteristic feature of the third method above mentioned is a froth, consisting off innumerable bubbles of air or gas, surrounded by a film of oil or other substance having the property of reducing the surface tension of water; the minerals are attached to these bubbles and thereby lifted, the gangue remaining behind in the pulp.

Nature of Phenomena

A great deal of study has been given to the theory of froth flotation and numerous papers have been written on the subject, to which the reader is referred for a full discussion. In this article the subject can only be touched briefly and simply. A flotation pulp is a complex mixture of finely ground minerals and gangue with water, air, flotation oils or reagents of one or more kinds, various salts in solution in the mill water, with possibly the addition of acid, alkali, salts or other addition agents. In the treatment of such a mixture it is apparent that a number of chemical and physical phenomena may be involved.

The interfacial tension theory of flotation has been elaborated by several investigators and seems to explain the complex phenomena satisfactorily, though other theories also appear to have some points in their favor. In the following brief explanation only the most essential part of the theory expressed in the simplest way will be given.

In the Macquisten and Wood machines, flotation of sulphides depends upon the principle that surfaces with a metallic lustre have a greater contact angle with water than those covered with a film of oxide or earthy substance. That is to say, sulphides are not readily wet by water and are supported by surface tension, while the gangue wets and sinks into the water.

When a needle or wire is floated on water in the well known experiment, the result is due to surface tension.

When finely ground ore is mixed with water and a contaminant such as oil, in a finely divided state, the oil is "adsorbed" by the mineral whereas the gangue particles are wet by the water in preference to the oil. It is upon this quality of certain mineral surfaces to adsorb the contaminant that flotation chiefly depends. When air in small bubbles is introduced into this mixture the oil or other contaminant tends to concentrate around the bubble, or is adsorbed by the air-water interface. In other words, the oil covers the bubbles with a thin film, thus making them more stable and permanent, due to the lowering of the surface tension of the water.

As a result of these two phenomena, the oil covered mineral particles are drawn into the oil film of the air-water interface, whereas the gangue, being wet with water, sinks away from the bubbles. It is also the claim of some investigators that the oiled mineral particles are supported in the watery film of the bubble at the air-water interface in exactly the same way that the mineral or needle floats on the surface of the water as described above. Possibly both causes operate to attach the minerals to the bubbles. The buoyancy of the air bubbles in the pulp affords a means of separation of the attached minerals, the froth rising to the surface, where it may be removed. There are numerous other physical phenomena that are considered to have a bearing upon flotation, as for example, the flocculation of colloids by certain acids and salts, the adsorption of gases by mineral surfaces, the electrostatic charges of the various minerals, etc. In addition, chemical reactions may take place between the oils, addition agents, minerals, air and water. Careful study of the many physical and chemical factors involved will, no doubt, explain practically all cases of abnormal results in the application of flotation.

Factors Necessary to Success in Froth Flotation

The essential factors for successful froth flotation are:

1. The ore must be finely ground, usually so that practically all will pass a 48 mesh screen.
2. The proportion of water to ore must be maintained within certain limits. Four of water to one of ore is a common ratio.

*By B. M. Snyder, of South Western Engineering Corporation.

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3. Careful adjustment of the kinds and amounts of oils added.

4. Salts, acids, etc., in the pulp water must be favorable.

5. Agitation and aeration of pulp are essential.

6. Regularity in the feed of pulp, reagents, etc., is necessary for the best results.

Minerals Separation metallurgists formerly thought that hot pulps were necessary or advisable for successful flotation, but it has been proven for some years that practically the same results can be had with cold water, and very few plants now heat their pulp water. While heat does reduce the surface tension of water, the effect is certainly not worth the tremendous expense incurred in heating pulps to 120° or 130° F., as was formerly the practice. The writer has performed satisfactory flotation with mountain water only a few degrees above freezing.

Lack of success in flotation mills is nearly always due to wrong conditions in one or more of the ways listed above. In some cases, the ore is not ground fine enough to free the minerals or to enable the latter to float. Very coarse mineral particles tend to drop back into the pulp and are naturally difficult to float. In other cases, too thick or too dilute pulps are sent to flotation. Dilute pulps reduce the capacity of the flotation machine and they should be thickened to about 4 to 1 ahead of flotation.

The kinds of oils or other frothing agents added are frequently the cause of poor results, though this cause is not as common as generally supposed. Almost invariably the oils used are blamed for poor results when the quantity of oil or other factors may be the real cause. Many operators use too much oil and often all that is necessary for good work is reduction of the quantity. Also some operators still make a complex mixture of oils in the belief that each adds some peculiar quality, whereas, in all probability, only one or two of them are essential. By the use of a good collecting oil, such as P.E. oil (of petroleum base) and a pure steam-distilled pine oil for frothing, practically all ores of every kind and description that are amenable to flotation can be successfully floated. All that is necessary is to vary the proportions and quantity of these oils added, provided always that other physical conditons are correct.

The function of the "collecting oil," as it is called, is to oil the mineral particles that are to be floated (the minerals "adsorb" the oil or are filmed by it), so that they will the more readily attach themselves to the air bubbles. The collecting oil may be coal-tar, wood-creosote, petroleum oil, or other heavy oil. It is best added at the ball mill, the grinding action serving to break it up into small particles, or, as it is termed, to "emulsify" it, though a true emulsion is not usually formed or desired.

The frothing oil may be pine oil, creosote, eucalyptus oil, oleic acid, etc., and serves the purpose of reducing slightly the surface tension of the liquid and thus promoting the formation of air bubbles. It may be added at the ball mill, also, though sometimes it is added just ahead of the flotation machines. Part of the frothing oil is usually soluble in water, and will, for this reason, be found with the gangue or tailings.

Some oils, for example, hardwood creosote and crude pine oils, have both collecting and frothing properties and may be used alone. Of recent years other contaminants than oil have been tried and in some cases used successfully, particularly in preferential flotation. Many of these are organic substances, derivatives of coal tar particularly being used. Among the organic compounds thus used are: phenol, phenolphtalein, alpha-naphthylamine, crude xylidin, etc.

Inorganic salts may also be used as the contaminant in place of oils, and sodium carbonate and bicorbonate are used in this way for preferential work, where a light and unstable froth is desired. Sea-water has also been used in place of oils for frothing purposes.

It will be seen that the use of oil is not an essential for froth flotation, and a certain amount of mineral can be floated by aeration in water alone. Oils serve the purpose, however, of stabilizing the froth and making the operation more regular and dependable, and are therefore almost universally used in flotation.

Addition Agents

The effect of soluble salts and "addition agents," so called, upon flotation is of the greatest importance. Frequently they are the key to success or failure in securing the desired results. They may be salts in the mill water, soluble constituents of the ore, or salts, acids or alkalies added to assist the flotation. In the early days of froth flotation, the Minerals Separation metallurgists thought that the use of sulphuric acid was necessary with most ores, but it has been found in recent years that as good or better results can be had without the use of acid, except in the case of a few ores, these mostly zinc ores.

Generally speaking, the best results are obtained with water containing a minimum of soluble salts. There are, however, many exceptions to this where a small amount of acid, alkali or neutral salt appears to be beneficial. In the case of zinc blende the addition of small amounts of copper sulphate or sulphuric acid seems to be needed for a good recovery. Whether or not this is due to the cleansing effect of the salt or acid on mineral surfaces has not been definitely proven. It is known that blende reacts with copper sulphate solutions, precipitating a film of copper sulphide on the mineral particles, and Ralston and Yundt consider this the reason for the improved flotation, copper sulphide evidently absorbing oil better than the natural zinc sulphide. Other theories advanced to explain the effect of salts and acids on the float are, that such substances flocculate or de-flocculate the colloids of the pulp, or that they flocculate the emulsified oil and make it available for oiling, as suggested by Van Arsdale.

Colloids in pulps probably have much to do with flotation results. As an indication of this may be mentioned the very detrimental effect on flotation of the addition of organic colloids such as glue, gelatin, albumen, etc. It is possible that addition agents may flocculate the colloids of oil, minerals, gangue, etc., and thus promote flotation.

The detrimental effect of very small amounts of soluble salts on the flotation of certain ores has been remarked by a number of operators. An in-

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vestigation of this subject has been made by the faculty and students of the Missouri School of Mines and Metallurgy, and the results have been published in a series of bulletins entitled "The Effect of Addition Agents in Flotation."

Among the most useful addition agents are sodium sulphide, sodium silicate, sodium carbonate, caustic soda, lime, copper sulphate, and sulphuric acid. The first of these is very commonly used in the flotation of carbonates and oxides. The effect of sodium sulphide is to convert a film of the carbonate or oxide into sulphide, which renders the mineral capable of flotation. This can be most easily demonstrated with lead carbonate, cerussite. The sodium sulphide quickly attacks the white cerussite forming a superficial film of black lead sulphide which floats readily. Sodium sulphide also assists in the flotation of certain sulphides, for example, iron pyrite. Whether or not this is due to filming of the partly oxidized particles has not been definitely proven.

Sodium silicate is an occasionally useful addition agent, and some recent experimental work on ore of a porphyry copper shows the grade of copper concentrate nearly doubled by its use in small amount. This is due to the dropping of iron pyrite when sodium silicate is added to the float.

Copper sulphate and sulphuric acid have already been referred to as necessary reagents in the flotation of most zinc blendes. The writer has used nitre-cake (acid sodium sulphate) to replace sulphuric acid in zinc flotation, and found it equally satisfactory, even when the acid content of the nitre-cake was almost nil as shown by titration with normal alkali solution. Very little more of such nearly neutral sodium sulphate was required than of sulphuric acid.

Copper sulphate has a detrimental action when present in small quantities in pulp water of copper mills. For example, at one of the Montana mills it was found difficult to get a good recovery of the copper minerals when the mine water, which contained a little copper sulphate, was used as the source of water supply for the flotation mill. The substitution of water free from copper sulphate immediately brought up the recovery. At one mill the writer found it impossible to get a good recovery of zinc from mill tailings unless the latter were thoroughly washed with water and the wash water decanted, fresh water then being added ahead of the flotation. As the decanted water carried over considerable colloidal gangue, it was at first thought the beneficial results were due to the removal of colloids, but careful tests and analyses indicated that the beneficial effect was due to the removal of a small amount of calcium and manganese sulphates and not to the washing out of the colloids. Many mill operators have noticed the detrimental effect of small amounts of salts in the mill water, and these should be thoroughly investigated when results are unsatisfactory.

The fifth feature mentioned above, agitation and aeration of the pulp, refers to the necessity of introducing large quantities of air in the form of small bubbles into the pulp, and agitation then insures contact of the oiled mineral particles with the bubbles, so that they may become attached and floated.

The sixth factor, namely, regularity of feed, density, reagents, pulp level, air, and other conditions, is of the greatest importance. Every operator finds it possible to get excellent results at times, but no so easy to maintain these results over extended production. The cause of unfavorable results is frequently the lack of regularity of feed. The ore may change in character, or the pulp may vary as to fineness, quantity fed to the flotation machine, etc. Variations in the amounts of oil, copper sulphate, sodium sulphide, or other addition agents naturally cause erratic results, and a frequent cause of such irregularity is the crude type of reagent feeder used. The remedy for this condition is obvious, namely, the installation of an accurate feeding device and the maintenance of constant quality of reagent.

The regularity of aeration is an important factor; the froth must overflow regularly or results will vary accordingly. In many small mills the inefficient power equipment and mechanical weaknesses of the plant make regular operating conditions impossible.

Apparatus for Aeration

Coming now to the apparatus used to effect the aeration, these may be divided into four general classes.

1. The vertical impeller type of machine, the original and best known of which type is the Minerals Separation machine. This type of machine beats in the air after the manner of an egg beater, the froth being skimmed off from a spitz-kasten connected with the agitation compartment.

2. The horizontal rotor type, the best known of which is the K & K machine. In this type the horizontal rotor picks up a film of pulp, which by centrifugal force is thrown off, together with intermixed air on to a skimmer plate which directs the pulp through a frothing compartment to the spitz-kasten, from which the froth overflows continuously.

3. The pneumatic type, the best known of which is the Callow Cell. In this type of apparatus, the air under pressure of a few pounds per square inch, is passed through a porous medium such as canvas, brick, cement bottoms, etc., by which means the air is broken up into small bubbles which rise through the column of pulp and overflow continuously.

4. The cascade type of apparatus has no moving parts, but depends for its aeration upon the air drawn in by falling or cascading from one vessel to another. This type of apparatus is not much used except as accessory to the others for recovery of small additional amounts of mineral.

Many of the machines in use are modifications or combinations of the above mentioned types, for example, the Janney mechanical-air machine is a combination of the first named type with the pneumatic type.

The froth will vary as to size and tenacity of bubbles according to the kind of machine in which it is made. For example, the first named type makes a very persistent froth, which breaks down with difficulty, while the horizontal rotor and pneumatic types make an evanescent froth. Needless to state the latter kind of froth is less troublesome to handle in the mill, since it breaks down almost as soon as it reaches the concentrate launder.

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The handling of the froth and concentrate in the mill has been one of the most troublesome things to work out in connection with the process. When the froth is persistent it can be broken down to a large extent by sprays of water. It is the usual practice to send the concentrate to a Dorr thickener, the thickened product of which goes to a vacuum filter. The filter product usually contains from 8% to 20% moisture and is ordinarily shipped to the smelter in this condition. In some mills, however, Lowden dryers are used to reduce the moisture content before shipping.

Preferential Flotation

One of the most important applications of the flotation process is the separation of sulphides in complex ores by what is called "preferential flotation." In this work a light froth is first produced and the more easily floated minerals, as for example, galena or chalcopyrite, are raised, leaving the iron sulphide, zinc blende, etc. Only a small quantity of oil, particularly of collecting oil, is used, but much air is introduced, with the result that only those minerals showing the strongest tendency to float are lifted. The pulp before passing to a second machine is mixed with more oil and an addition agent, such as sodium sulphide, acid, or salts of various kinds, thus changing the conditions and enabling the froth to bring up one or more of the minerals present. The addition of sodium sulphide in the second flotation will frequently bring up the pyrite, which may be floated off separately. Following this, the addition of acid or copper sulphate will bring up the zinc blende and in this way three products may be taken off. Similar schemes are used on other ores and the work so far done indicates the great possibilities of the method.

In Table No. 1 the results of a preferential flotation test are given. This test (A) was on ore considered very difficult to treat by any method known and large bodies of the ore were available in the district awaiting a solution of the problem of separation of the minerals.

A number of reagents for use in preferential flotation have been proposed and some are now in commercial use. They assist in one of two ways: (1) by taking the place of oil as the contaminant (as with "diamide," "X-cake," etc.); (2) by deadening or enlivening certain minerals through the deposition of a film that retards or assists oiling, as the case may be. Sodium sulphide and hydrogen sulphide usually assist flotation, while sulphur dioxide, sulphites, and reducing agents in general have a retarding effect.

Treatment of Oxidized Ores

Another very important development of the flotation process is its application in the treatment of oxidized and carbonate ores. Several mills have been successfully operated using the method of sulphidizing metallic ores or carbonates and floating the mineral. It is found that on many oxidized minerals sodium sulphide will deposit a superficial film of sulphide which will then absorb oil and become floatable. Among minerals that are particularly amenable to this treatment are lead carbonates and some copper oxides and carbonates. The recovery of the metals by this method is not as high as with sulphides, and in the case of lead carbonate ranges from 70% to 90% of the lead contained. There is room for considerable study and experiment along this line and much progress is to be expected in the future. In Table No. 1, Test B shows results on a copper oxide ore, obtained by sulphidizing and straight flotation. Test C shows the results obtained by sulphidizing and flotating a typical lead carbonate ore carrying small silver values.

Among mills that have been, or are now operating on lead carbonates by sulphidizing and floating are the Shattuck Arizona Copper Co., Slate Range Minerals Co., and the recently completed 150-ton plant of the Signal Mining Co. The latter is treating carbonate ores of the old McCracken Mine in Western Arizona, and is reported to be making a tailing assaying less than 1 ounce silver from 20 ounce ore.

The Magma Copper Co. has for several years treated its copper oxide and carbonate ores by sulphide filming, using hydrogen sulphide gas for this purpose. According to the results published by J. M. Callow, the recovery on clean carbonate ore ran from 73% to 83% of the copper content.

Another scheme that appears promising is the treatment of mixed sulphide and oxidized ores by a combination of leaching and flotation, as developed at Chino and other places. Sulphuric acid is added to dissolve the oxidized copper, and the pulp is then run through a rotating cylinder containing iron, access of air being prevented as far as possible to avoid oxidation of the finely precipitated cement copper. Oil is then added, the mixture passed to a flotation machine and the resultant froth carries both the sulphide copper and the metallic copper in a high grade concentrate. Test D in Table No. 1 shows the result of a small scale test on an ore containing copper as carbonate and sulphide. A cheap supply of acid and iron is essential to the success of this process, and ores containing much lime cannot, of course, be treated with acid economically. As a possible cheap source of iron for this process, the reduction roasting process seems worth considering. By this method hematite can be cheaply reduced on the ground, it is claimed, affording a sponge iron that should be very suitable for the purpose.

Recovery of Petroleum by Flotation

It is now proposed to use flotation in the recovery of crude petroleum and asphalt from oil sands, and application for patent on the process has been made. The scheme consists of breaking up the oil sands in a log washer using water and a small amount of solvent, which may be any of the cheaper grades of petroleum distillates. The pulp then passes to a flotation machine and the resultant froth carries nearly all the oil and solvent together with entrained sands which are removed by a second and third treatment in cleaner cells. Tailings from the first treatment are clean and white and nearly free from petroleum oil and solvent; experimental tests show recoveries as high as 97% can be readily made. A 300-ton plant is planned to test the feasibility of the process for recovery of petroleum from a large surface deposit of oil sand. The low recovery of petroleum from oil sand by drilling and the high recovery possible by direct treatment on the surface may mean, if the demand for oil warrants it, a change in methods of production, that is, the mining of the oil sands and flotation or other suitable treatment at the

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surface. This may be far in the future, as underground mining of oil sands presents many problems, but if the price of oil warrants, it may become a reality.

Results and Costs

In Table No. 2 are given some results obtained in actual mill operations in both large and small plants. It will be noted that in some of the mills the recovery is not as high as might be expected of flotation, but it must be remembered that many of these properties, particularly the porphyry coppers, are treating ores containing more or less oxidized mineral on which the recovery is very low.

Flotation mills are less costly to build than most other treatment plants of the same capacity, and operating costs are usually low in comparison, also. The total milling cost of the porphyry coppers runs from 50c to $1.00 per ton. The costs at one of the large copper mills, in which flotation plays a leading part, are given:

	Year 1920
Crushing and grinding	$ .282 per ton
Flotation	.0674 per ton
Tabling	.0122 per ton
Other costs	.1542 per ton
Total milling	$ .5158 per ton

At another porphyry copper the total milling cost was $.72 per ton for the year 1920, and at still another the corresponding figure for 7 months of 1921 was $.908 per ton ore. The Engels Copper Co. total milling costs for the year of 1920 were $1.2407 per ton, treating about 1,000 tons of ore daily. Kennecott milling costs for the year 1921 were $.719 per ton, treating an average of 600 tons daily. All of the figures quoted were made in years of excessively high cost for both labor and supplies, and would now undoubtedly be much lower.

TABLE NO. 1

		ASSAYS				DISTRIBUTION PER CENT.			
Test		% Weight	Oz. Silver	% Copper	% Lead	% Zinc	Silver	Copper	Lead	Zinc
A	Heads	100.00	1.94		6.85	7.41			100.0	100.0
	Lead Conc.	7.65	19.6		71.20	5.10			79.0	5.3
Complex Lead-zinc-pyrite ore. Preferential flotation.	Lead Mids.	3.16	.....		20.80	18.80			9.6	8.0
	Zinc Conc.	9.26	2.8		2.10	47.20			2.8	59.1
	Zinc Mids.	5.22	.....		20.80	18.80			2.8	10.5
	Tailing	74.71	.79		.50	1.70			5.4	17.1
B	Heads	100.00		2.00				100.0		
	Conc.	11.91		12.35				73.5		
Copper in ore, mainly copper oxide, sulphidized and floated.	Mids.	12.06		2.57				15.5		
	Tailing	76.03		0.29				11.0		
C	Heads	100.00	2.67		23.91		100.0		100.0	
	Conc.	31.77	3.72		56.40		44.3		75.0	
Lead carbonate ore, sulphidized and floated.	Mids.	11.91	7.94		24.24		35.4		12.0	
	Tailing	56.32	0.96		5.52		20.3		13.0	
D	Heads	100.00	.32	1.56			100.0	100.0		
Mixed sulphide and carbonate copper ore. Copper leached and precipitated, then sulphides and metallic copper floated.	Conc.	1.94	10.20	70.81			62.5	87.8		
	Mids.	8.09	1.48	1.83			37.5	2.6		
	Tailing	89.97	Tr.	.05			Tr.	2.6		

TABLE NO. 2—MILL RESULTS

Combined Gravity and Flotation Concentration			Assays			% Recovery	
Mill	Ore	Average For	Mill Heads	Concentrate	Tailing	Total Mill	Sulphide
Inspiration	Copper	1 day, May, 1917	Cu. 1.3%	Cu. 29.7%	Cu. .35%	73.96	91.47
Surf Inlet (B. C.)	Gold	 1918	Au. .6 oz.	Au. 8.2 oz. (F) Au. 5.36 oz. (G)			**Flotation**
Nevada Consolidated	Copper	4 months	Cu. 1.49%	Cu. 12.59%	Cu. .30%	92.2 81.6	44.4
Kennecott Copper Co.	Copper	Year, 1921	Cu. 5.62%	Cu. 49.01%	Cu. 1.35%	77.82	
Braden	Copper	Year, 1921	Cu. 2.258% Pb. 14.3%	Cu. 25.47% Pb. 68.0%	Cu. .358% Pb. .5%	85.58 87.0	
Zinc Corp. (Australia)	Lead-Zinc	 1918	Zn. 9.2% Ag. 2.6 oz.	Zn. 43.0% Ag.	Zn. 2.0% Ag. .5 oz.	60.0 68.2	
Flotation Only			**Flotation Heads**				
Engels Copper	Copper	Year, 1920	Cu. 2.21%	Cu. 29.76%	Cu. .45%		80.93
Mount Lyell	Copper	Year, 1919	Cu. 3.43%	Cu. 10.95%	Cu. .45%		90.41
M. Co. (Mexico)	Copper	10 days, 1919	Cu. 3.337%	Cu. 14.29%	Cu. .545%		85.3
National Lead	Lead	1 month, 1922	Pb. 4.0%	Pb. 55.0%	Pb. .4%		90.6
Silver Mill (Mexico)	Silver	2 months	Ag. 11.27 oz.	Ag. 1189. oz.	Ag. 1.5 oz.		86.0
Leadville Mines (Nev.)	Silver-Lead	1 day, 1921	Ag. 19.06 oz. Pb. 3.48%	Ag. 212.8 oz. Pb. 35.4%	Ag. 1.16 oz. Pb. .28%		94.6 92.7
S. Co. (Colo.)	Lead-Zinc	1 month, 1918	Pb. 3.85% Zn. 4.8% Ag. 4.1 oz.	Pb. 47.58% Zn. 44.0% Ag. 1st conc. 40.73 oz. 2nd con. 15.70 oz.	Pb. .40% Zn. .42% Ag. .48 oz.		71.42 77.92 1st conc. 54.71 2nd conc. 32.56

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TESTING ORE FOR FLOTATION*

The factors involved in the concentration of ores by flotation are so few in number and so readily applied in a small way that it is possible to gain a fairly accurate idea as to the character of the concentrate that may be obtained by flotation, and even the total percentage of recovery that may be made by this process, by means of simple apparatus and small quantities of ore.

Purpose of Tests

It may be the purpose of the testing to determine the character and value per ton of the concentrate that will be yielded if all the metalliferous constituents of the ore are recovered as a single product; to determine the percentage of recovery of the metals that may be won by the concentration, or to recover one or more of the metalliferous constituents of the ore in a concentrate separate from the others. This last, selective flotation, is capable of a degree of development requiring very careful selection of the flotative and modifying agents to be used, and will not be discussed here.

The recovery of the metalliferous constituents of the ore in a single concentrate is not a very difficult task if the ore is amenable to treatment by flotation, and any test by which the operator wishes to determine the general characteristics of the concentrate to be produced or the total recovery possible by floating all the floatable contents of the ore together may be made with some kind of standard mixture of oils and tars that will be generally applicable. Various oil mixtures have been used for this purpose by different operators. A mixture of three parts Pensacola Tar & Turpentine Co.'s No. 400 pine creosote or its equivalent, three parts of carbolic creosote, and one part of crude coal-tar or pitch, makes a satisfactory combination for general testing purposes. For pyrite alone, the No. 400 pine creosote is usually satisfactory. Others have found crude pine-oil plus 10 to 25% of crude coal-tar satisfactory.

Bottle Test

The simplest apparatus for testing ores by flotation is a good-sized clear-glass bottle. A quart bottle will do very well for 100g samples of ore. An ordinary acid bottle, such as those in which acids are sold, may be used on samples up to 500g. To carry out the test, the bottle should be washed clean and half filled with the crushed ore and water in the proportion of one part by weight of ore to from two and a half to four parts of water; using a quart bottle, a pint of water and 200g of ore may be used and the test may be started with five or six drops of oil; using an acid bottle, half a bottle of water and 500g of ore make a good charge, and from six to twelve drops of oil are used at the start. After the oil is added to the pulp the bottle should be shaken violently with an up-and-down or horizontal movement and brought to a stop in a vertical position, using care to leave as free from rotary motion as possible. If the ore is especially adapted to flotation and the correct amount and kind of oil have been used a considerable portion of the metalliferous constituents should rise to the top of the pulp as a froth. After the slime has settled this froth may be removed by carefully raising the water-level in the bottle by adding water through a funnel, the lower end of which is below the water-level, or by pouring water carefully down the neck of the bottle. The sides of the interior of the bottle should be wetted first by pouring clear water slowly into the neck of the bottle. After the froth has overflowed completely the bottle may be permitted to stand until the pulp is settled sufficiently so that the excess water may be siphoned off, and the operation may be repeated with or without the addition of further amounts of oil. This operation may be repeated until it yields no more froth. The bottle-test may be repeated upon an ore, using one oil after another, until an oil or mixture is obtained that gives the best results. This test is helpful in selecting the proper oil-mixture to use in a mill or in more elaborate tests. It is also helpful in the field or in the mill, for arriving quickly at a qualitative test which will indicate the nature of the concentrate that may be obtained from any particular ore.

As a qualitative test it may be of a great value in the hands of the mill-foreman or shift-boss in testing the tailings from flotation machines or from vanners and tables, and in testing the overflow from de-watering devices, to see how much fine sulphide they contain. No equipment is needed other than a clear-glass quart botle and a bottle of the oil or oil mixture that has been found suitable for the ore, this bottle being equipped with a good drop-stopper.

The bottle test may be made to yield quick quantitative results of fairly reliable kind if it is manipulated skilfully, repeated agitation being used until no further concentrate is produced. A simple method of expediting the work is to take an india-rubber sack or "baloon." If one of these, attached to the end of a glass tube, is introduced into the bottle after the agitation has taken place, water may be introduced into the sack through tube and the water-level raised so that the concentrate overflows without the pulp being diluted. The rubber sack may then be emptied by siphoning and the operation may be repeated with the minimum loss of time. If a rubber bag is not available, a sheep's or pig's bladder might serve as a satisfactory substitute.

On certain ores a modification of the bottle-test may be carried out effectively where the desired effect is not a process to be used in practice but to get a quick idea of what kind of concentrate the metalliferous constituents of the ore will yield when separated from the gangue.

Bottle Test With CO_2

The manipulation is as follows: To the pulp in the bottle may be added from 1 to 10% of limestone, ground sufficiently to pass an 80-mesh screen. The oiling and the agitation may be carried on as before. A sufficient amount of sulphuric acid may now be added to start the generation of CO_2 in the pulp, and the bottle may be filled with water so that the froth as it rises will overflow into the pan in which the bottle is set. By keeping the pulp stirred with a long rod or tube the sulphides may be completely removed by flotation, if the proper amount of the oil best adapted to the work is used. This manipulation requires some skill and is not

*By James M. Hyde. From Mining and Scientific Press, October 2, 1920.

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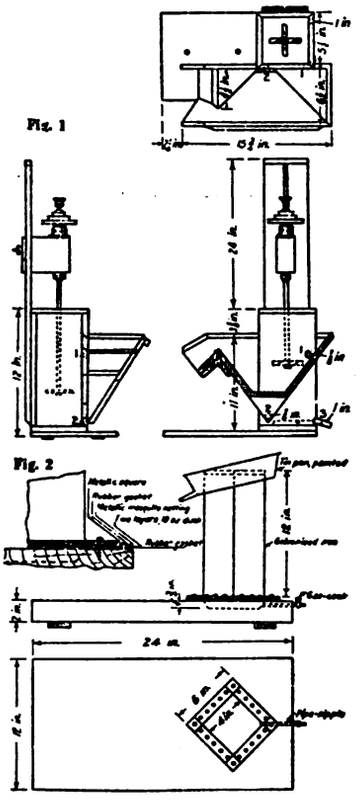
recommended for general use; but, like the other bottle-test, it may be advantageous if no other equipment is at hand than that with which the bottle-test can be made. If the pulp is heated, or if the amount of sulphuric acid added is too large, the gas may be generated so rapidly as to expel the pulp from the bottle. For this reason the acid should be added carefully, and with stirring, so that the generation of gas will be kept within bounds. The acid may be added before the agitation takes place, if sufficient care be used, in which case the test may be completed more quickly than by any other means, as it may be possible to raise the concentrate completely at one time; but this is not recommended because the generation of gas may be so rapid as to throw the acid pulp out of the bottle onto the operator. The mouth of the bottle should always be pointed away from the operator.

Mechanical Flotation Tests

For making flotation tests by mechanical means, a simple apparatus will give reliable results with either the agitation or the pneumatic process. Many types of apparatus have been used and described in the technical press, but the two described herein are very simple and have yielded quite satisfactory results.

The machine for carrying out the froth-agitation flotation process consists of a rectangular box in which agitation takes place, and a pointed box in which the froth separates from the rest of the pulp. See Fig. 1. The pulp is kept in continuous agitation and continuous circulation from the agitation chamber through an opening 1 into the separation chamber or spitzkasten from which it returns to the agitation chamber through the opening 2. The impeller has blades set at an angle of 45° from the vertical, and is placed about half-way between openings 1 and 2. The impeller is adjustable as to height and may be raised so that the agitation chamber is completely open for inspection or cleaning. Ordinarily the impeller is adjusted until the best position is found and then left at that position.



The method of procedure in making a test with this machine is to close the opening 1 with a cork, introduce water up to a point just below this opening, and start the impeller. The dry ore is now added and mixed thoroughly with the water, water being added until the level in the separation chamber is about half an inch below the height of the overflow lip. The oil or oily mixture to be tested is added in the proper amount. Where a 500g charge is used the initial addition of oil need not be more than from six to ten drops, unless previous testing has shown that as much as ten or fifteen drops are needed. The oil is added most conveniently by means of a 1 cc pipette graduated to hundredths. After a sufficient mixing of the oil and pulp has taken place, which should be in about half a minute, the cork may be removed from the opening and the pulp allowed to circulate; from time to time, the froth floating upon the surface of the water in the separation chamber may be removed by a paddle and further additions of oil may be made in small amounts so long as they continue to produce more froth. After the last concentrate is removed, the tailing may be discharged through the opening 3. The machine is washed out conveniently by means of a stream of water from a hydrant or other source, carried through a rubber tube and a piece of glass tube 13 to 14 inches long, drawn to a tip at the bottom, and the tip inclined at an angle to the body of the glass tube, thus permitting a jet to be applied to the floor of the agitation chamber in such a way as to wash the sand to the discharge opening with the use of the minimum amount of water. After the machine has been cleaned thoroughly the concentrate may, if desirable, be returned to the machine and refloated in order to raise its grade, the tailing from this operation forming a middling product, which normally would go back to the tube-mill or other fine grinder, for regrinding and return to the flotation machine with regular feed.

The chief individual merits of this apparatus are that it is driven from overhead, the height of the impeller is adjustable, and the settling-chamber is adequate, and is so arranged that the pulp circulates thoroughly without the use of any piping. The impeller in a machine of this type should be driven at a speed of 800 to 1600 revolutions; 1200 is usually about right.

Pneumatic Machine

The pneumatic machine shown in Fig. 2 is useful and can be constructed cheaply. It consists essentially of a wooden base into which is sunk a recess, to be used as an air-pocket into which air is introduced from some simple blower through a gas-cock and short nipple. Over the air-pocket in this base is placed, first, a square rubber gasket, then two thicknesses of 10 oz. duck or its equivalent, then a square of ordinary metallic mosquito netting, and a second rubber gasket, above which is mounted a square metallic cylinder open at each end (having a flange at the bottom as indicated and a basin at the top to receive the concentrate as it overflows), this basin being equipped with a spout by which the concentrate as it overflows is directed into the collecting basin. That portion of the edge of the canvas which goes under the flange may be saturated with asphalt, care being taken that it does not permeate the portion of the canvas going under the inner portion of the cylinder. The cylinder is attached to the wooden base by a number of screws, and is screwed down in place so tightly that no air or water will escape through the edge of the canvas. The flange which is made by bending up pieces of the sides, should be reinforced by a square with the centre cut out. A small mechanical blower, such as the Crowell blower, is useful for this machine. Such a blower should be equipped with a pop-valve which may be set for any desired pressure by adding or removing weights.

A test is performed in this apparatus as follows: 500g of ore is mixed with 1250 to 1500 cc of water

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in an acid-bottle, which is shaken to wet the ore and make a homogeneous pulp. To this is then added from 6 to 15 drops of the oil or oil mixture to be used in the test. The pulp is shaken vigorously until the oil is well mixed with the whole of the charge, as described in the bottle test. The oiled pulp is now poured into the cylinder, the air is turned on and carefully regulated by the gas-cock so that the overflow of the concentrate will take place gently. This froth is overflowed until all of the concentrate the sample will yield has been produced. The tailing may be removed from the machine by tipping it up on the end of the base away from the air-intake while the air is still turned on, and washing out the contents with a jet of water. The concentrate may be returned to the machine and refloated.

Crushing

A representative sample should be carefully crushed to such a size that even the coarsest piece of sulphide mineral will float readily. In some ores pyrite is of little or no value, and it is often desirable to float other sulphides without floating the pyrite. Ordinarily, pyrite is tougher than the other sulphides, and it may be possible to determine a degree of crushing that will leave at least a portion of the pyrite too coarse to float, while practically all of the chalcopyrite or other sulphide that it is desired to save may be fine enough for successful flotation. If it is desirable to leave part of the pyrite unfloated, a test may be made upon ore crushed so that it will all pass through a 30 to 50-mesh screen. Ordinarily, where it is desirable to float all the sulphide constituents of an ore, the whole sample should be crushed so that it will pass through a 60-mesh screen. Even 100-mesh or finer gives the best results in most cases, especially for the bottle-tests.

In testing an ore for the purpose of working out the details of milling practice the tests should be made upon samples crushed to different degrees of fineness in order to determine how fine it is necessary to crush to get the maximum recovery, and whether or not a finer degree of crushing is necessary to get the highest grade of concentrate possible.

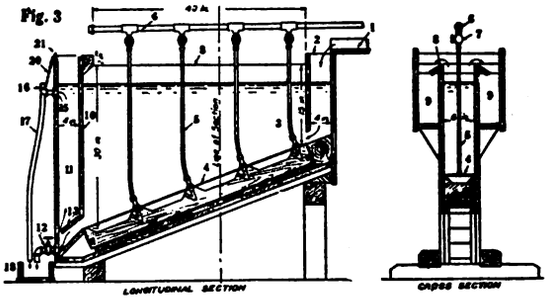
Oils

The usual oils or oil mixtures used in flotation work include turpentine, crude or refined; steam-distilled pine-oil, and the whole range of products recovered by the destructive distillation of pine-wood, falling generally under the head of pine-creosotes and pine-tars; the creosotes and tars produced in the destructive distillation of hardwoods; the neutral and acid creosotes, and refined and crude tars produced in the destructive distillation of coal; and certain crude oils and petroleum distillation products. Qualitative tests may often be made with salad-oil, if nothing better is at hand. Small amounts of pine-creosotes and tars, may in a pinch be made by distilling pitch-pine, oak, maple, alder, etc., or coal-tars, in some simple retort.

Value of Tests

The simple mechanical apparatus described herein will give satisfactory and reliable tests, but much of importance can be learned by the bottle-tests, and they may be constantly used to advantage around an operating mill. The agitation and the pneumatic machines are entirely adequate for making elaborate studies of flotation problems, changing all factors, such as kind and amount of oil, dilution of pulp, fineness of ore, the use of additional reagents, such as lime, ferrous sulphate, copper sulphate, sodium hydroxide, sodium sulphide, and sodium silicate. Where ore is to be ground dry and many tests are to be made, a quantity of the ore should be mixed thoroughly after grinding and screening, and portions of the pulp to be tested should be weighed out into a number of paper sacks to facilitate rapid work. Some ores do not float readily if they have been dried; so, in checking mill-work, the drying of ores and the grinding of them dry should be avoided.

Fig. 3



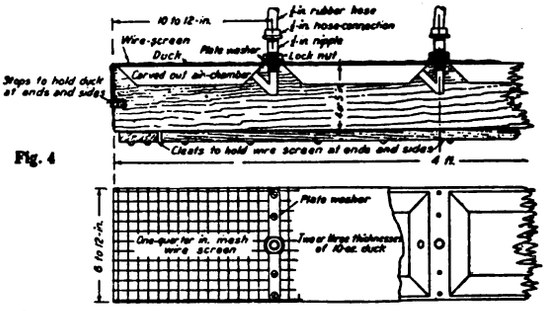


Fig. 4

Filtering

Large Buechner filters, with filter-pumps attached, may be used where many samples are being handled. Where few samples are being handled and assays do not have to be made promptly a wick filter may be used satisfactorily. A single paper towel folded to about an inch wide and flattened with the end held by a wire paper-fastener may be wetted and one end put in the pan of concentrate, the other end being folded over the edge of the pan and brought down below the bottom of the pan. Capillarity will remove the water at a surprising rate. If the pan is set on the edge of a sink, the water may be allowed to go to waste as it is removed or it can be caught in a pan. When the sample is air-dry the concentrate on the wick-filter may be brushed off. This simple device is very useful in removing water from samples of mill-pulp containing slime. Such a sample may be decanted after a reasonable length of time if a pinch of alum is added to it when it is collected. After all the water than can be safely removed is poured off, a further amount may be taken off with a wick filter and the pulp brought to a thick consistency ready to go into a steam-dryer or to be used for flotation tests.

Larger Pneumatic Machine

A cheaply constructed continuous machine of the pneumatic type can be constructed with a tank of wood or galvanized iron, the air cells being carved out of a straight grained piece of redwood or pine timber. Such a machine, as shown in Figs. 3 and 4, is very useful in testing under mill conditions. The measurements given may be varied as desired.

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A machine 4 ft. long and 6 in. wide with 2 sq. ft. of canvas surface was built some years ago for a total cost of less than $50.

The body of the machine is a rectangular tank with a sloping bottom or false bottom, and overflow sides. One overflow side will do for testing. Pulp from the launder 1 (see Figs. 3 and 4) enters the feed chamber 2 and flows into the flotation chamber, where it passes over the wooden air-cells 4, through the upper canvas surface of which compressed air is being forced. The air is applied through the hose 5 from the header-pipe 6. Each air-cell is regulated independently by a valve 7. The air rising through the previously oiled pulp builds up a fed of mineral-bearing froth above the water level; this froth flows continuously over the lip 8 and is carried away by the launder 9. The bed of fragile froth, which readily breaks down unless air is constantly bubbling up beneath it, is prevented from flowing over the tailing discharge, where no air is rising, by a partition 10 that divides a dead-water space 11 from the frothing-chamber. The bulk of the tailing is discharged through the valve 12. The deflector 13 guides any bubbles carried toward the tailing-valve by the flow of the pulp back into the frothing chamber. The deflector 14 causes a counter-current of froth to flow toward the feed end of the machine. Slime-tailing flows through the opening 15 and the swing-pipe 16 and through the hose 17 and joins the sand-tailing in the main tailing launder 18. The swing-pipe 5 may be fastened at any desired height by engaging the proper link of the chain 20 over the nail 21. When the valve 12 is set so that it does not permit all the tailing to flow through it, the position of the swing-pipe fixes the height of the water level, which will not vary until the pipe is re-set.

A Device for Flotation Experiments, by Will H. Coghill, Min. & Sci. Press, April 12, 1919. The device recommended here has been used at the North-West station of the U. S. Bureau of Mines at Seattle. It consists of two pyrex flasks, one of 250 cc and the other of 500 cc capacity. A rubber nipple is placed on the neck of the smaller one, so that when the flaring portion is ground off it will fit snugly into the larger. To prepare a test, the smaller flask is filled with a mixture of ore and water of the desired consistency and emptied into the larger one, after which about three cubic centimeters of water is added. After the desired flotation reagents have been added, a stopper is placed in the flasks and we are ready to proceed with the test.

The procedure of testing is by means of hand agitation for, say, five minutes. The stopper is removed, the flasks are united, and, after a brief agitation, they are placed so that the 250 cc flask stands upright. The extra 3 cc of water elevates the lower level of the froth so that it will overflow into a collecting-pan when the larger flask is removed. The agitation may be repeated as often as desired by adding a little extra water each time.

The efficiency, of course, is low as compared with the mechanical devices, but the relative floatability of minerals and the relative effects of flotation reagents may be determined quickly. There are two reasons why the efficiency is low: first, there is no opportunity for the froth to build up during the agitation period; second, a small quantity of gangue lodges on the bench formed by the union of the inner and outer tubes, and by joining the overflow reduces the grade of the concentrate.

The quantity of modifying reagents must be determined by calibrated devices; otherwise impressions may be misleading. This is demonstrated by the following example. When four drops of oil were added from a medicine-dropper the pyrite floated so freely that the results were adverse. The dropper was then calibrated, and it was found that four pounds of oil per ton of ore had been used. The test was then repeated with one drop of oil and the results were encouraging.

Flotation Tests on Zinc Tables Slime

Purpose of Experiment

To provide mine owners with facts concerning amenability of their table slimes to flotation. It should be remembered that flotation concentrates of zinc tenor bear a penalty because of fineness. The term "table slime" or discharge should not be confused with "table sludge" or feed.

Amount of Slime Available

Reports indicate 9 per cent. of total mill feed is sent to thickeners as "slime." Slimes for this experiment were obtained from the Dorr Thickener of the Golden Rod Mining & Smelting Corporation, Tar River, Okla., contained 25 per cent. moisture and showed the following analysis in per cent.:

CHEMICAL ANALYSIS OF TABLE SLIME

Zn	13.77
Fe	0.92
CaO	6.83
MgO	5.41
Pb	0.76
"Insoluble"	55.51
Total determined	83.20

A screen analysis, using Tyler Standard Screens, showed following results:

SCREEN ANALYSIS OF TABLE SLIME

On Mesh	Diameter Opening, Inches	Sample Weights	Per Cent.	Per Cent. Cumulative Weights	Per Cent. Zinc
65	0.0082	.....	.....	.....	.....
100	0.0058	9.28	2.25	2.25	2.18
150	0.0041	73.70	17.83	20.08	3.63
200	0.0029	124.50	30.13	50.21	12.17
—200	0.0029	205.70	49.79	100.00	15.35

From preliminary tests with a Janney test machine it was found that the A. T. Mixture (alpha naphthylamine and ortho toluidine) from the Newport Chemical Company of Passaic, N. J., used with copper sulphate produced results so good that further research was confined to this combination.

Method of Conducting Experiment

700 gr. dry ore mixed with 5 parts of tap water was mixed in machine, .75 lb. of oil to 1 ton of ore added and agitation continued. Then copper sulphate was added and "concentrate" was skimmed. "Middling" was then skimmed until no blende was apparent in the froth. The total time for test was twenty minutes.

Copper Sulphate Consumption

Best results were found when 2 pounds copper sulphate were added per ton of slime, i. e., 70 c. c. of 1 per cent. solution in the experiment.

Calculation of Recovery

The recovery was calculated by the following formula:

$$\frac{\text{(Weight of concentrate} \times \text{per cent. Zn)} + \text{(Weight of middling} \times \text{per cent. zinc)}}{\text{Weight of Charge} \times \text{per cent. Zn}}$$

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Results tabulated below have been checked from one to three times:

RESULTS OF EXPERIMENTAL FLOTATION WORK

Test No.	—Oil— Amount, Drops	Kind	—Reagent— Amount, C.C.	Kind	—Results— Concentrate Wt. Grams	Per Cent. Zn	Middling Wt. Grams	Per Cent. Zn	Tailing Per Cent. Zn	Recovery, Per Cent.
1	8	A.T.	30	$CuSO_4$	48	54.70	39	41.44	8.12	44.0
2	Drops	Mixture	40	in	98	54.91	20	43.60	5.09	65.0
3	in	in	50	every	120	57.91	27	43.30	2.34	84.0
4	every	every	60	test	130	58.74	25	40.92	1.31	88.5
5	test	test	60		130	58.33	27	39.16	1.40	88.0
6			70		150	57.08	17	26.31	1.22	92.0
7			70		150	58.84	12	32.43	0.58	95.0
8			70		148	58.64	14	31.50	0.61	95.0
9			80		150	58.42	17	23.41	0.60	95.0
10			90		149	58.70	16	22.81	0.59	95.0

Edward H. Robie, in his paper on "The Use of Naphthylamin and Xylidin in Flotation," Engineering and Mining Journal, Vol. 108, No. 18, page 731, makes the following statement: "When operating with X-cake-kylidin, economy requires the use of the largest possible amount of return water. . . . Apparently little or no deterioration occurs in settling ponds, although the water gradually turns a dark brown. Considerably less of the agents under discussion are therefore required if the make-up water is kept at a low proportion of the total."

To verify the above statement several series of tests were run in the following manner:

One of the weighed charges was run as previously described. This test has been designated as No. 1-A. The water from test No. 1-A was siphoned off and used for the next test. No oil was added, but the same amount of copper sulphate was found to be necessary. This test was called No. 2-A. The water from test No. 2-A was siphoned off and used in like manner for test No. 3-A. The froth which formed in test No. 2-A had the same characteristics as that formed in No. 1-A. The froth in test No. 3-A, although it did not appear to be as stiff as in tests No. 1-A and 2-A, carried practically as much blende. One set of these results is tabulated below.

EXPERIMENTS TO SHOW PERSISTENCE OF A. T. MIXTURE

Test No.	—Oil— Amount, Drops	Kind	—Reagent— Amount, C.C.	Kind	—Results— Concentrate Wt. Grams	Per Cent. Zn	Middling Wt. Grams	Per Cent. Zn	Tailing Per Cent. Zn	Recovery, Per Cent.
1-A	8	A. T.	70	$CuSO_4$	153	57.00	25	12.43	1.01	95.0
2-A	None	Mix-	70	$CuSO_4$	148	57.71	26	21.76	0.81	95.0
3-A	None	ture	70	$CuSO_4$	149	58.22	18	21.86	0.92	95.0

Conclusions Based on the Test Work

1. Copper sulphate is the main factor in the concentration of the blende in this slime by flotation.

2. The "A. T. Mixture" of the Newport Chemical Company, of Passaic, N. J., in conjunction with copper sulphate, was the oil best suited to float the blende in this slime. The amount of oil used in each test is equivalent to 0.75 lb. per ton or dry ore.

3. The best results were produced by 70 c.c. of a 1 per cent. solution of copper sulphate, this amount being equivalent to approximately 2 lb. per ton of dry ore.

4. Small amounts of copper sulphate added at intervals did not raise the blende as well as when added all at one time.

5. The oil must be added first. When the copper sulphate was added to the charge before it was poured into the machine, practically no blende floated.

6. The consumption of oil may be lowered considerably by returning the water from the concentrate and tailing to the flotation cells.

—Abstracted from Article by M. H. Thornberry in Engineering and Mining Journal, January 4, 1922.

FROTH FLOTATION OF COAL

The application of the flotation process to the purification of coal, while put into practice only recently, has already attracted considerable attention from the industry. As an illustration, we would cite the recent description given by Mr. P. G. Peterson of the Peterson cell, 8′ 6″ in diam., having an approximate capacity for 50 tons for 24 hours, in his recent presidential address to the British Columbia Section of the Canadian Mining Institute. The purpose of the test described was to ascertain the suitability of the flotation procses for cleaning Vancouver Island coals. The process in brief is as follows:

The coal pulp is dropped into the bottom of the cell and air is added, a heavy, oily froth, black with coal particles, is formed, which passes over a weir. With flotation a stiff froth lifts the coal above the slate so readily that the coal and tailings discharge can be made at levels further apart than with jig washing. Not only is coal lighter than slate, but it is more readily carried by the froth and would be so carried were it even heavier than the slate.

The best results were obtained when using an oil mixture that produced a voluminous froth. The actual weight used varies with the kind of oil, but in general 10 pounds of oil is all that was required to float a ton of coal, and in some cases 2 pounds of oil per ton of coals loaded were found to be sufficient.

Flotation is best suited to the recovery of coal from fine material. Coal washing tables are an effective means of cleaning coal coarser than 60 mesh, and it is only with sizes finer than this that flotation willl be useful. This offers exceptional opportunity for the treatment of coal high in ash so intimately mixed with the coal substance that fine grinding is a necessity.

In a recent article in "Chemical and Metallurgical Engineering," by O. C. Ralston and A. P. Wichmann, they make the statement that flotation of furnace and household ashes on a large scale could be performed with advantage. They also state that semi-anthracite and coking coals are the most amenable to flotation, but sub-bituminous coals can also be floated. Among the reagents used by them were X-Cake with zylidine to effect solution, kerosene-pine oil, coal tar-pine oil, coal tar-hardwood-oil and hardwood-oil creosote.

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CHEMICALS AND FLOTATION OILS

Obviously, aside from the problem of obtaining the greatest possible recovery of mineral by the use of any suitable flotation oil, one of the most important considerations is the utilization of the less expensive oils.

The principal sources of the supply of these oils are three: petroleum and its products and by-products; by-products from coke ovens and gas retorts; and various derivatives in the distillation (both steam and destructive) of various woods.

Hundreds of miscellaneous oils have been experimented with, but with few exceptions commercial plants operate on a combination of the products mentioned above. While no rules can be set down, the usual function of the various oils is known in a general way. A good oil mixture for any given ore must contain elements for (1) oiling (selectively) the concentrate minerals, and (2) forming a sufficient volume of froth to carry the concentrate.

It has been the custom to divide flotation oils into two large classes, the frothing oils and the collecting oils. This is done mainly because some oils seem primarily to reduce the surface tension of the water, while others seem to affect the interfacial tension and to produce a non-wet film of, perhaps, molecular dimensions, around mineral particles. The latter are the collectors, the former the frothers. This view does not appear to be quite sound. It seems that we cannot draw such a sharp line of demarcation between these two types of oils. It is perhaps more correct to state that some oils exert a very marked influence on the nature of the froth, a property which in a measure obscures the other properties of this oil. Other oils, again, seem to affect the froth very slightly because of their cohesive and coating properties. By carefully studying the above-stated functions of a flotation oil, one will readily see how impossible it will be to produce one oil for the treatment of all ores. One oil cannot possibly combine all these properties as required for all types of ores. These factors are all variables in different cases, and in most instances the problem of successful flotation for any given ore requires its own solution.

Oils answering the first requirement are usually the least expensive, and it is common to use a comparatively large percentage of such an "oiler" with a small amount of a "frother," or "foamer." Certain lubricating oils, Texas crude petroleum and especially crude coal tar, are cheap but satisfactory oilers, and form a basis of many mixtures. Lighter oils, more or less miscible or soluble in water, have frothing characteristics as a rule, and include pine oil, pine tar oil, wood creosote, coal tar creosote and other light tar oils, eucalyptus oil and turpentine, as suggested. Small proportions of these last are generally mixed with the cheaper products.

Coal Tar Oils

Practically every product of coal tar has been used in the process, but the principal ones at the present time are the various crude tar fractions, including tar itself. As a source of various materials for use in flotation operation, three fractions are taken off and used as a raw material in further manufacturing operations. The lightest fraction which comes off is commonly known as light oil, the second fraction creosote oil, and the third containing the higher boiling fractions is Pitch of different grades. The majority of the flotation oils are those obtained from the light oil or creosote

Wood Oils

Frothing quantities of Wood Oils:

Crude Wood Turpentine	Thin ephermal froth.
Pine Oil	Thin ephermal froth.
Refined Tar Oil	Large amount ephermal bubbles.
Tar Oil	Large amount, large stiff bubbles.
Crude Wood Oil	Large amount, large stiff bubbles.
Pine Tar	Large amount, large stiff bubbles.
Hard Wood Creosote	Small bubbles, stiff froth.

The Standard Products are known as:

Pine Oil—Steam distilled, light straw color, specific gravity 0.920 to 0.940.

Pine Oil—Destructively-distilled, straw yellow in color, specific gravity 0.910 to 0.930.
either alone or blended with various materials of many specific gravities and acid contents.

Pine Tar Oil—Double-refined, color reddish, transparent, gravity 0.935 to 0.975.

Pine Tar Oil—Dark Brownish, specific gravity 102 to 105.

Wood Creosote—May be as dark as Tar Oil, as well as partly transparent, specific gravity 0.950 to 1.070.

Pine Tar—Brownish black, specific gravity 105 to 109.

Crude Wood Turpentine — Destructively-distilled, reddish in color, specific gravity 0.975 to 1.000.

In some instances the Turpentine is distilled off and all the rest left in one fraction, containing all the Tar and Tar Oils, including the Pine Oil. These oils are used at some mines. Again others use what is known as the middle fraction; that is, the Turpentine is distilled off at the beginning and at the end a residium of pitch is left.

The most successful flotation oils so far produced are products of the long-leaf pine tree. There are two different types of products from the pine tree, the one is the steam-distilled, the other the destructively-distilled oil. The steam-distilled pine oils have given far better results in the flotation field than have the destructively-distilled oils. Some have found that in the use of the so-called pine-tar or destructively-distilled pine oil the froth is liable to break, with the result that the mineral concentrate is precipitated, especially in the case of long contact with acid solution. In some cases, however, pine-tar oils give a fairly good froth. A brief consideration of the steam-distilled pine oils which have given such uniformly excellent results in the flotation process may be of some interest here. These pine oils are produced from the Long-Leaved Pine or Pinus Australis. The source of the pine oil is the dead heart pine wood, stump and knot. The origin of the oil is not well established. Some of its constituents are related chemically to pinene found in turpentine. All of its constituents belong to the class known as "terpenes," and the most important of these are terpineol, fenchyl-alcohol, borneol, camphene, phenols and terpinene. Some believe that the pine oil occurs in a different part of the wood-structure than the turpentine.

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Whatever the real origin of the oil, it is a product of very specific and distinct physical and chemical characteristics.

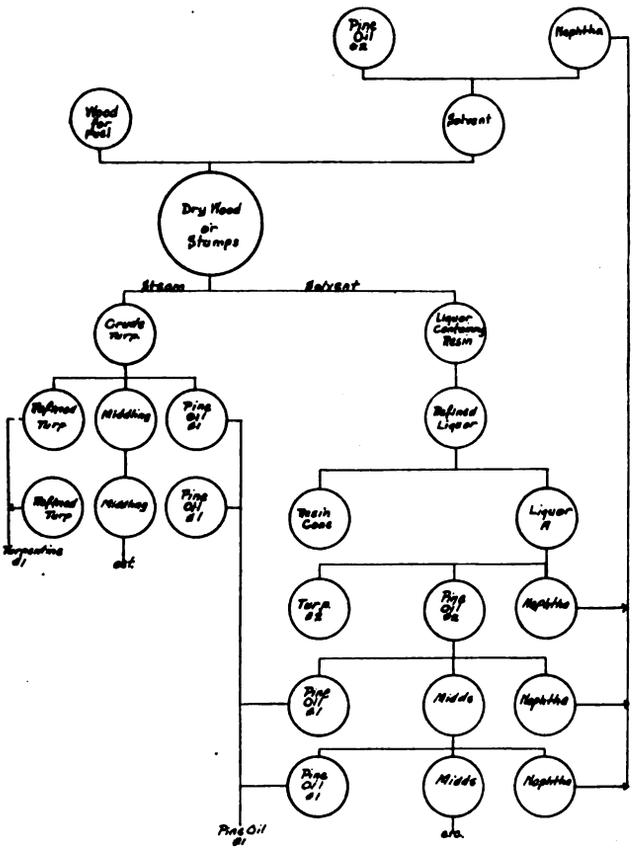

Diagram Showing Process of Extraction of Steam Distilled Pine Oil.

In the steam-distillation process the pine oil is extracted from the wood which has been chipped into extremely fine fragments by means of a solvent at a high temperature. The solution contains all the resins as well as the various pine oils. By means of the new methods of refining and distilling a pine oil of a specific gravity anywhere between 0.875 and 0.995 can be produced. It is possible not only to produce pine oils of any such desired gravity, but also to remove all traces of foreign substances, whether added in the manufacturing process or present in the original raw material.

The final product, steam-distilled pine oil, is a light straw-colored oil with a very pleasant odor. This oil has a refractive index ranging between 1.4797 and 1.4815 at 20° C., an acidity of less than 0.1%, and a free water-content of less than 1%. The polymerization residue of steam-distilled pine oil of 0.935 gravity is less than 5%, with an index above 1.4850. A comparison of specific gravity and refractive index is a safe means of determining the purity of the oil. The minimum index ought to correspond with the minimum gravity. Should the oil be adulterated with mineral oil, for example, the gravity will be lowered, but the index will be higher than that which ought to correspond with that given gravity. The amount of mineral oil in such a mixture can be determined by means of the sulphuric acid—polymerization residue method. The flash point of a highly refined pine oil is about 76° C. by the open cup method.

Hard Wood Oils

Hard Wood Oil—Destructively-distilled from hard wood, by-product of wood alcohol and acetate of lime, brownish in color, specific gravity 0.940 to 0.980.

Hard Wood Tar—Brownish-black, gravity 107 to 109.

Hardwood Creosote on Differential Flotation

In the course of flotation experiments being conducted by the Moscow, Idaho, field office of the U. S. Bureau of Mines, in co-operation with the Simon Silver-Lead Co., of Mina, Nev., it has been found that hardwood creosote alone gave a fair differential separation of the galena and sphalerite. In combination with sodium dibasic phosphate, a marked flotation of the galena in preference to the sphalerite was given. Sodium carbonate and creosote gave better results than creosote alone, the same being true for potassium permanganate.

Western Wood Oils

As a result of investigation made jointly by the School of Forestry and the School of Mines of the University of Idaho, in co-operation with the State Bureau of Mines and Geology, to determine the availability of western wood oils for use in the Flotation process, we are able to give the following summary of results obtained:

The purpose of the study was to determine:

(a) The possibility of obtaining wood oils suitable for use in flotation concentration from the commercial species of Idaho woods.

(b) To determine the yield of oil obtainable from each species; and

(c) To determine the possibility of producing oils having a reasonable degree of uniformity with reference to their flotation properties.

Species of Wood and Estimated Amount Available:

Red or Douglas Fir—20 to 27 billion board feet.
Western Yellow Pine—16 to 22 billion feet.
Lodgepole Pine—11 billion feet.
Western Larch—Tamarack—6 to 7 billion feet.
Western Red Cedar—4 billion feet.
White or Grand Fir—5 billion feet.

Yields were obtained of from 10.6 gallon per cord with White Fir, to 55 gallons per cod with Western Yellow Pine, the relative cost of production ranging from 5.3 to 1 respectively.

Conclusions From Results of Tests:

From the Tests made on Idaho ores of various kinds, using the oils recovered from these woods, it was considered safe to conclude:

(1) That good flotation oils can be produced by the destructive distillation of the commercial wood species occurring in Idaho.

(2) That of the woods distilled, the oils produced by the destructive distillation of Port Orford cedar are, in general, the most satisfactory, comparing favorably with the best flotation oils in the market.

(3) That the oils produced by the destructive distillation of lodgepole pine, red fir and larch are good flotation agents compared with the standard oils used.

(4) That the oils produced by the destructive distillation of western red cedar, yellow pine and white fir may be classed as fair flotation agents compared to the standard oils used.

(5) That large quantities of the various species of wood are available for destructive distillation either in stands, as saw mill waste or as stumps in land clearing.

(6) That, in general, under favorable conditions, the production of flotation oils from western woods is commercially feasible in connection with the manufacture of other forest by-products.

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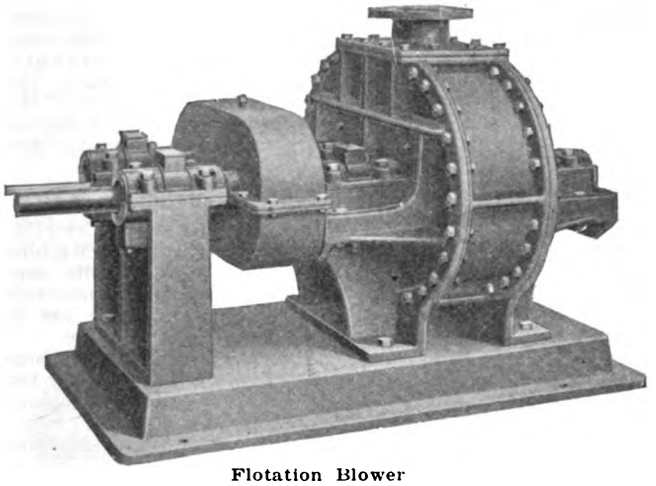
Flotation Blowers

Modern flotation processes have created a need of blowers to deliver the air against pressures of from 5 to 10 pounds per square inch with varying



Flotation Blower

volume requirements. Connersville High Pressure Blowers were used for the experimental work along these lines and the results obtained were so satisfactory that they are generally adopted for flotation installations.

For these higher pressures the cylinders and impellers of the blowers are shortened, bringing the journals closer together. By decreasing the distance between the journals in proportion to the pressure the bearing and gear loads remain practically constant. Double outer-bearings support the shaft beyond the gear-housing. As the blower and outer bearing are mounted on a one-piece base plate, each machine is a strong compact unit.

Connersville High Pressure Blowers are offered in capacities from 25 cubic feet per minute up and for pressures ranging up to 10 pounds per square inch. Bulletin 23M describes and lists these blowers in detail.

Smelter Blowers

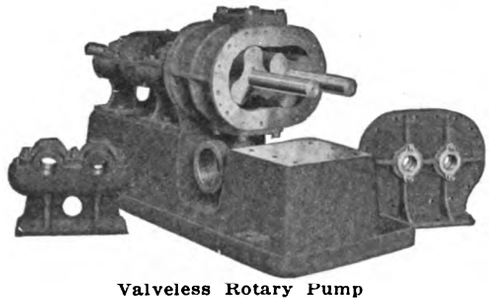
When smelting furnaces were small, the blowers of small sizes and for low pressures served them successfully. But with the advent of larger and deeper furnaces, blowers of greater capacity and increased strength were required. This led to the development of the Connersville Smelter Blower.

These smelter blowers are built in a complete range of sizes up to and including 400 cubic feet per revolution and are furnished with either a single pair of gears or double geared drive.

The driving power of blowers already installed in smelters have been furnished through direct connected steam engines, rope drives, motor drive through belt, water wheel, etc. Some of these are illustrated in Catalogue 18M, which also supplies engineering data.

Valveless Rotary Pumps

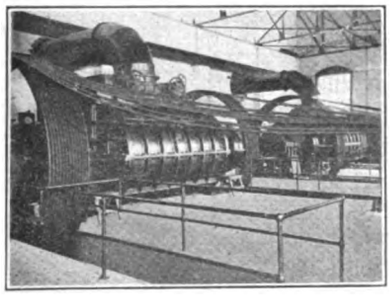
Not only are these pumps suitable for pumping oils, water and other liquids, but they are used to produce vacuums. Air or gases and liquids can be



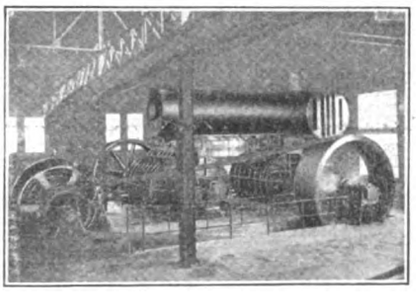
Valveless Rotary Pump

handled simultaneously. They are equally successful as wet or dry vacuum pumps, and will not be injured by a slug of water.

The application of this type of pump to metallurgical processes has been general, it being used wherever vacuum filtration or drying of sands or concentrates is carried on.



Smelter Blowers at Work



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Groch Centrifugal Flotation Co.

509 Mills Building, EL PASO, TEXAS

Oil Flotation—Ore Testing—Mill Designing

Products

Groch Centrifugal Flotation Machines; Houston Belt and Disc Feeders; Diaphragm Pumps; Roasting Furnaces.

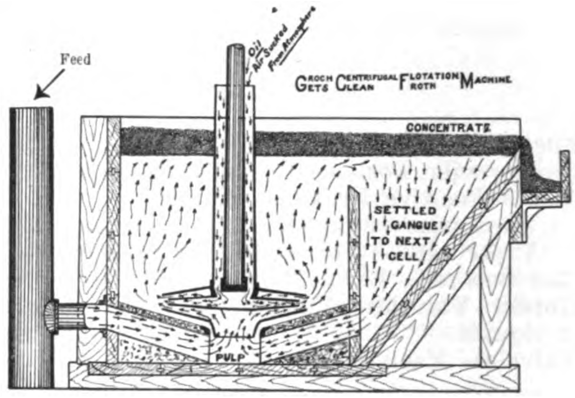
Engineers for the design and construction of concentration, amalgamation and cyanide plants.

Uses

The Groch Centrifugal Flotation Machines are used for the recovery of valuable minerals from their ores. The **differential** recovery of lead and copper from ores containing zinc and later recovering the zinc is accomplished in the same machine.

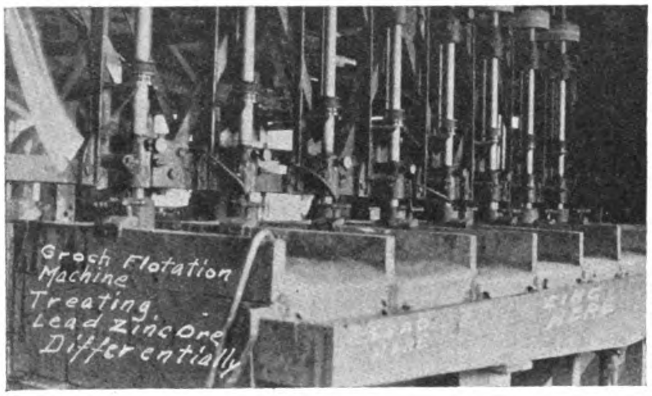
Agitation where strong agitation with air is desired.

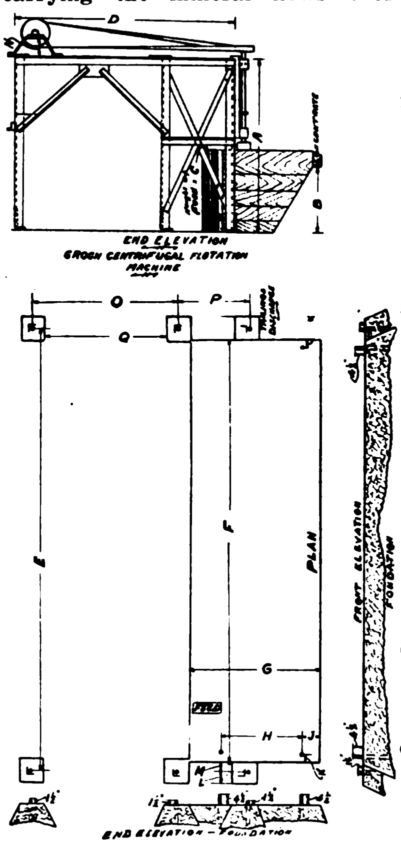
For saving wood fibre, which is now lost in paper mills.



The whole mass rises and flows over a weir into the settling chamber, where the current is quieted and the froth carrying the mineral flows over into the concentrate launder, after dropping the gangue.

The settled product is drawn to the next impeller, where the process is repeated, and thus continues until the tailings are automatically discharged from the machine.





Principle of Operation

The Groch Impeller operates like a steam ejector, excepting that the pressure on the pulp is caused by the centrifugal action of the impeller, which sucks the pulp up from the agitation chamber, and throws it out from the top and bottom sections of the impeller, thus creating a vacuum at the periphery of the middle section which causes the air to be sucked down the hollow shaft from the atmosphere.

The oils and chemicals are fed down the hollow shaft, where the air enters.

The impeller atomizes the oil, therefore the air is oiled before it strikes the pulp. **This is a distinct Groch feature.**

The ground ore and water, forming a pulp, is fed under the floor of the first cell. The impeller sucks it up within itself, where it meets the oiled air.

This aerated pulp is thrown outward from the impeller into the agitation chamber, where the pulp and air bubbles rise, with all of the advantages of both pneumatic and mechanical flotation systems.

Advantages

The Groch Centrifugal Flotation Machine will **differentially** separate different minerals from the same ore in the same machine.

The Groch Machine uses less power per ton than any other machine on the market.

The Groch Machine gets clean concentrates and a high extraction.

The Groch Machine is easy to operate. It is practically FOOL PROOF.

Tonnage

The Groch Machine is made in all sizes from twenty-five to five hundred tons per day in one machine.

We also make a laboratory machine which gets mill results.

GENERAL DIMENSIONS OF GROCH CENTRIFUGAL FLOTATION MACHINES

Cells	Size	Style	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	Approx. Wt. Lbs.
2	12" Impeller	Belted	7' 0"	2' 0"	3' 11"	9' 0"	4' 8½"	3' 9⅝"	5' 5½"	2' 2⅞"	9"	2¾"	6"	5 7/16"	10½"	6' 0"	2' 11 11/16"	5' 0"	3000
4	12" Impeller	Belted	7' 0"	2' 0"	3' 11"	9' 0"	8' 0"	7' 1⅛"	5' 5½"	2' 2⅞"	9"	2¾"	6"	5 7/16"	10½"	6' 0"	2' 11 11/16"	5' 0"	5900
6	12" Impeller	Belted	7' 0"	2' 0"	3' 11"	9' 0"	11' 3½"	10' 4⅝"	5' 5½"	2' 2⅞"	9"	2¾"	6"	5 7/16"	10½"	6' 0"	2' 11 11/16"	5' 0"	6300
8	12" Impeller	Belted	7' 0"	2' 0"	3' 11"	9' 0"	14' 7"	13' 8⅛"	5' 5½"	2' 2⅞"	9"	2¾"	6"	5 7/16"	10½"	6' 0"	2' 11 11/16"	5' 0"	9600
10	12" Impeller	Belted	7' 0"	2' 0"	3' 11"	9' 0"	17' 10½"	16' 11⅝"	5' 5½"	2' 2⅞"	9"	2¾"	6"	5 7/16"	10½"	6' 0"	2' 11 11/16"	5' 0"	11000
12	12" Impeller	Belted	7' 0"	2' 0"	3' 11"	9' 0"	21' 2"	20' 3⅛"	5' 5½"	2' 2⅞"	9"	2¾"	6"	5 7/16"	10½"	6' 0"	2' 11 11/16"	5' 0"	13500
4	18" Impeller	Belted	8' 0"	2' 6"	4' 7"	9' 0"	12' 4½"	11' 7"	6' 9"	5' 0"	3"	2¾"	6"	4¼"	10½"	6' 0"	2' 11 11/16"	5' 0"	8000
6	18" Impeller	Belted	8' 0"	2' 6"	4' 7"	9' 0"	15' 1"	14' 3½"	6' 9"	5' 0"	3"	2¾"	6"	4¼"	10½"	6' 0"	2' 11 11/16"	5' 0"	12000
8	18" Impeller	Belted	8' 0"	2' 6"	4' 7"	9' 0"	17' 9½"	17' 0"	6' 9"	5' 0"	3"	2¾"	6"	4¼"	10½"	6' 0"	2' 11 11/16"	5' 0"	15000
10	18" Impeller	Belted	8' 0"	2' 6"	4' 7"	9' 0"	20' 6"	19' 8½"	6' 9"	5' 0"	3"	2¾"	6"	4¼"	10½"	6' 0"	2' 11 11/16"	5' 0"	19000
12	18" Impeller	Belted	8' 0"	2' 6"	4' 7"	9' 0"	23' 2½"	22' 5"	6' 9"	5' 0"	3"	2¾"	6"	4¼"	10½"	6' 0"	2' 11 11/16"	5' 0"	22000
4	18" Impeller	Motor		2' 6"	4' 7"			11' 7"	6' 9"	5' 0"	3"	2¾"							8500
6	18" Impeller	Direct		2' 6"	4' 7"			14' 3½"	6' 9"	5' 0"	3"	2¾"							12500
8	18" Impeller	Connected		2' 6"	4' 7"			17' 0"	6' 9"	5' 0"	3"	2¾"							16000
10	18" Impeller	To Each		2' 6"	4' 7"			19' 8½"	6' 9"	5' 0"	3"	2¾"							20000
12	18" Impeller	Impeller		2' 6"	4' 7"			22' 5"	6' 9"	5' 0"	3"	2¾"							23000

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SOUTHWESTERN ENGINEERING CO.

INCORPORATED

Ore Testing-Treatment Plants Designed and Erected

Offices

1221 Hollingsworth Bldg., LOS ANGELES, CALIFORNIA

Factory: Culver City, California

Branch Offices

410 Hegeman Bldg., 200 Broadway, New York City

16 de Septiembre 5, Mexico City, Mexico

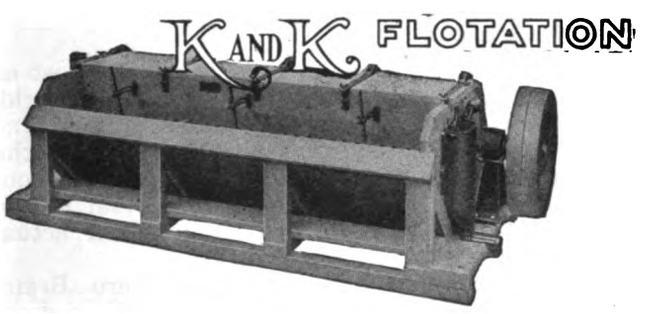
Consulting Mining, Metallurgical and Mechanical Engineers

Products

K & K Flotation Machines; Southwestern Ore Feeders; Kraut Oil Feeders; Vibrating Screens; Southwestern Steam Condensers; Gasoline Condensers; Dephlegmators; Air Inter and After Coolers; Gas Coolers and Heat Exchangers.

K & K Flotation Machines

K & K Flotation Machines are of the horizontal rotor type. The pulp enters one end of the machine and is picked up and aerated by the rotor, the froth overflowing from the Spitz into a launder. The



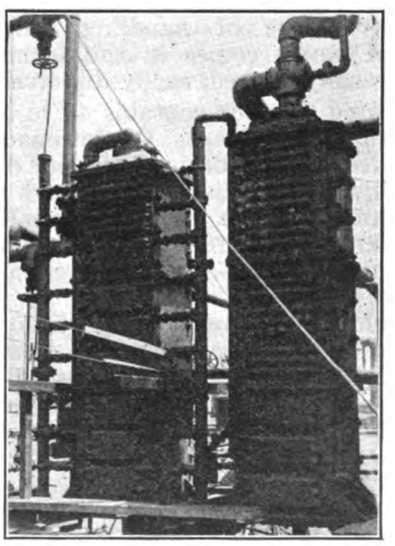
pulp is aerated a number of times in its spiral course through the machine and is discharged at the other end as a clean tailing.

The K & K Machine is entirely self-contained, requiring no blowers, air-pipes or accessories. Over four hundred of them are now in use in flotation mills everywhere.

We carry the following Mill Supplies: Chrome Steel Balls; P. E. Flotation Oil (Collecting Oil); Pine Oils (Frothing Oils); Sodium Sulphide, Sodium Cyanide, and other heavy chemicals.

TYPES OF K & K FLOTATION MACHINES

Type	Shipping Weight Lbs.	H. P. to Run	Capacity per 24 Hrs. Tons
A-2612	4200	7-10	75-100
A-2610	3800	6-8	50-70
A-2608	3000	4-6	25-40
A-2606	2400	3-5	10-25
A-1808	2000	3-5	10-25
A-1806	1500	3-4	8-15
A-1804	1200	2-3	5-8



Southwestern Condensers at a California Refinery

LITERATURE UPON REQUEST:

K & K Flotation Machine Catalogue (5th Ed.)

Bulletin A-3—Coolers

Bulletin O-5—Condensers

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AMERICAN CYANAMID COMPANY

511 Fifth Avenue, NEW YORK

Manufacturers of

AERO BRAND CYANIDE

Product

Aero Brand Cyanide is an air-nitrogen product made at Niagara Falls, by an electric furnace process.

History and Use

Aero Brand Cyanide was first produced in January, 1917, with an initial production the first year of about 1,000,000 pounds of sodium cyanide equivalent, which has been steadily increased so that the production of 1922 will exceed 15,000,000 pounds of actual sodium cyanide equivalent. Its use had become almost universal for the extraction of gold and silver from their ores, under all conditions of cyaniding practice.

Advantages

The distinct advantages of Aero Brand Cyanide in ore extraction are:

(1) Low cost of a unit of cyanogen at point of consumption.
(2) Extraction efficiencies on both gold and silver ores equal to those with any other grade of cyanide.
(3) Consumption of cyanide the same as when other cyanides are used.
(4) Inert materials in Aero Brand Cyanide assist in coagulating the slimes and accelerating the clarification and filtering of the pulp from solutions.
(5) Convenience of handling. Aero Brand Cyanide comes in the form of flakes, easily poured, easily dissolved.

Aero Brand Cyanide contains 48 to 50 per cent sodium cyanide equivalent. Quotations are always made, however, on the basis of 100 per cent sodium cyanide equivalent. This should always be borne in mind in comparing the price of Aero Brand with that of other grades. (100 per cent sodium cyanide is equivalent to 132.85% potassium cyanide or 53% cyanogen.)

Although freight and transportation costs on Aero Brand Cyanide are more than on higher testing cyanides the prices quoted on Aero Brand make the delivered cost of the pound of actual 100 per cent sodium cyanide, as a general rule, lower than on any other cyanide product.

Packing and Appearance

Aero Brand Cyanide is in the form of shiny, grayish-black flakes, about 1/16 of an inch thick and of irregular area from 1/4 square inch to about 3/4 square inch. It is packed in heavy air-tight galvanized steel drums, holding about 200 pounds net, 216 pounds gross weight.

In cases where pack-mule transportation is necessary drums of two sizes are provided, one holding 100 pounds net, 110 gross, the other 135 pounds net, 150 gross. These drums are specially designed, are made of heavy galvanized iron and will withstand severe handling and tropical cimates.

Mill Practice

The only recommendation made for its use is that, if possible, Aero Brand Cyanide be dissolved in a tank before being added to the mill circuit, and while the dissolving action is taking place the material be agitated, preferably by a mechanical stirring device. If any quantity of the material is allowed to settle together, the hydration of the lime present may raise the temperature considerably, and cause local decomposition of the cyanide, forming ammonia gas. The method of adding a continuous solution of cyanide to the mill circuit will be found to be of advantage in better control of the cyaniding operation from a milling standpoint. In many cases, however, Aero Brand Cyanide is added directly to the agitators, or tube mils, but in all such cases a plentiful supply of water or barren solution should be present to effect the proper dissolving action.

Results Obtained

Aero Brand Cyanide is being used by most of the cyanide consuming mines throughout the world. Extraction efficiencies on all classes of gold and silver ores and the consumption of cyanide in the mill circuit, have been shown by six years of continuous operation to be consistently equal to the results obtained with an equal amount of actual sodium cyanide in any other form.

The main inert ingredients in Aero Brand Cyanide, in addition to the 48 to 50% sodium cyanide equivalent are sodium chloride, calcium chloride, lime, and a small percentage of insoluble matter. The calcium chloride and the free lime exert a coagulating effect upon the slimes, resulting in more rapid separation of the solutions from the pulp. The remaining ingredients have no influence whatever upon the regular operations of the cyanide mill.

Other Uses

In addition to its extensive use for cyaniding gold and silver ores, thousands of tons of Aero Brand Cyanide are converted per annum into liquid hydrocyanic acid, in California, for fumigation of citrus fruit groves.

We also produce Aero Brand Case-Hardening compounds, ready for immediate use in all kinds of steel-treating wherever cyanide is used, and metal cyanides, namely copper cyanide, zinc cyanide, and silver cyanide, for electro-plating.

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THE CLEVELAND-CLIFFS IRON CO.

CLEVELAND, OHIO

Headquarters for

Hardwood Flotation Oil

Products

Hardwood Flotation Oil, destructively distilled and especially prepared for copper, lead and silver ores. Frothing and carrying properties unexcelled.

Specifications for our standard grades are as follows:

No. 1 Light Oil

Specific Gravity at 15° C.—1.020 to 1.035
Phenols Cresols 30%.
Average weight per gallon 8.58 lbs
Distillation (typical)

up to—	100° C.	6%
	125° C.	10%
	175° C.	12%
	190° C.	14%
	200° C.	20%
	210° C.	34%
	220° C.	53%
	230° C.	64%
	240° C.	73%
	250° C.	80%
	260° C.	85%
	270° C.	88%
	280° C.	92%

No. 2 Medium Oil

Specific Gravity at 15° C.—1.050 to 1.070
Phenols Cresols 10 to 12%.
Average weight per gallon 8.84 lbs.
Distillation (typical)

up to—	100° C.	8%
	150° C.	20%
	190° C.	22%
	200° C.	23%
	210° C.	28%
	220° C.	38%
	230° C.	48%
	240° C.	58%
	250° C.	63%
	260° C.	68%
	270° C.	75%
	280° C.	78%

XX Heavy Oil

Specific Gravity at 15° C. average 1.095
Phenols Cresols 5% to 10%.
Average weight per gallon 9.12 lbs.
Distillation (typical)

up to—	140° C.	4%
	220° C.	6 to 10%
	230° C.	10 to 20%
	240° C.	20 to 25%
	250° C.	25 to 30%
	260° C.	30 to 35%
	270° C.	35 to 40%

We are equipped in our research and experimental laboratories to meet any specifications for Hardwood Creosote Oils. Plants at Marquette, Gladstone and Antrim, Mich. Samples furnished free. Write for information to

THE CLEVELAND-CLIFFS IRON CO.

Kirby Bldg., Cleveland, O.

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GENERAL NAVAL STORES CO.

90 West Street
NEW YORK

DENVER, COLO.
1535 Nineteenth Street

CINCINNATI, OHIO
Union Central Building

CHICAGO, ILL.
McCormick Building

GNS FLOTATION OILS

Effective Oils of Each Class

We offer a complete line, Oils secured in the Steam Distillation and Destructive Distillation of Pine Wood, Hardwoods and Coal Tar.

Steam Distilled Pine Oil

G.N.S. No. 5 OIL.

This is the most widely used Flotation Oil. Alone, it is most effective on many silver, lead, zinc and graphite ores. In mixtures with other oils, especially Coal Tar Creosote, it is commonly used on copper ores. No. 5 is a Pure Steam Distilled Pine Oil distilled from selected old wood. The process used allows such close control over the product that this Oil is kept peculiarly uniform in quality and is effective in phenomenally small quantities. Our experience indicates we are not warranted in offering other grades of Steam Distilled Pine Oil for Flotation work, cruder forms apparently carry useless diluents.

Hardwood Oils

G.N.S. No. 17 OIL.
G.N.S. No. 18 OIL.

These Oils carry all the effective oily constituents found in Northern Hardwood. In the No. 18 there is a higher percentage of Hardwood Tar.

Destructively Distilled Pine Products

G.N.S. No. 4 D.D. PINE OIL.
G.N.S. No. 8 PINE TAR OIL.
G.N.S. No. 9 REFINED TAR OIL.
G.N.S. No. 14 PINE TAR.

When Pine Wood is distilled down to Charcoal, the vapors are collected into a complex crude. The above oils derived from this crude embody the distinctive qualities found in this class of oils. They are more generally favored on copper ores and have also proved effective on a variety of other ores.

Coal Tar Creosotes

G.N.S. No. 20 COAL TAR CREOSOTE.
G.N.S. No. 22 COAL TAR CREOSOTE.
G.N.S. No. 25 COAL TAR CREOSOTE.
G.N.S. No. 26 COAL TAR CREOSOTE.
G.N.S. No. 28 COAL TAR.
G.N.S. No. 29 CRESYLIC ACID.

Oils of uniform quality that emphasize the peculiar flotation properties found in this class of product.

SAMPLES FOR EXPERIMENTAL PURPOSES FURNISHED

TURPENTINE **ROSIN**

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HERCULES POWDER CO.

WILMINGTON, DELAWARE
NAVAL STORES SALES OFFICES
Salt Lake City, Utah, 1019 Kearns Bldg. New York City, 120 Broadway Chattanooga, Tenn., 934 Volunteer Bldg.
Chicago, Ill., 1440 McCormick Bldg. San Francisco, Calif., 1002 Chronicle Bldg.
Distributors for Canada: Canadian Explosives, Ltd., Montreal Distributors for Mexico: Western Purchasing Co., El Paso, Tex.

Steam Distilled Pine Products for Flotation

Hercules Flotation Oils

It has been clearly demonstrated in the testing laboratories, as well as in the flotation mills of this country, that pine oil, and in particular steam-distilled pine oil, is the flotation frother par excellence. Steam distilled pine oil is the regular standard in terms of which the frothing qualities of any flotation oil or oil-mixture are measured, whether the mineral to be tested be a lead, zinc, copper or silver ore.

The Hercules Powder Company's three plants, situated at Brunswick, Ga., Hattiesburg, Miss., and Gulfport, Miss., together constitute approximately sixty-five percent of the total plant capacity available for the production of steam-distilled pine oils. The manufacture of this large amount of oil is under the direct supervision of our Chemical Department working in conjunction with our Operating Department. Hercules pine oils have been standardized into six flotation oils. The specifications of these oils are given below, and all of these constants are guaranteed.

Yarmor—A Steam Distilled Pine Oil

Yarmor is the highest grade pine oil made and is primarily a frother, producing a profuse, rather fine-grained froth. It is used successfully in combination with the crude collecting oils on many types of ores, but particularly on zinc and copper. The favorite mixture is 15% Yarmor and 85% Crude Coal Tar, Hardwood Creosote or Fuel Oil.

SPECIFICATIONS

Specific Gravity at 15° C.	0.933-0.938
Unpolymerized Residue, not over	5%
Refractive Index at 20° C. not under	1.480
Viscosity, Saybolt, 100° F. very close to	46.1
Flash Point, Abel Closed Cup, not under	65° C.
Color	Straw
Avg. Wgt. per gallon (lbs.)	7.78

Distillation: (typical)

5%	189° C.	40%	208° C.	80%	214° C.
10%	198° C.	50%	210° C.	90%	217° C.
20%	204° C.	60%	212° C.	95%	222° C.
30%	206° C.	70%	213° C.		

Remoh—A Steam Distilled Pine Oil

Remoh is not quite as highly refined as Yarmor. In many instances, however, it gives just as good results as the higher grade and more expensive oil. It is always advisable, when searching for the most efficient frothing oil, to test both Yarmor and Remoh oils.

SPECIFICATIONS

Specific Gravity at 15° C.	0.920-0.925
Unpolymerized Residue, not over	10%
Refractive Index at 20° C. not under	1.478
Viscosity, Saybolt 100° F., very close to	41.5
Flash Point, Abel Closed Cup, not under	60° C.
Color	Straw
Avg. Wgt. per Gallon (lbs.)	7.68

Distillation: (typical)

5%	185° C.	40%	203° C.	80%	212° C.
10%	190° C.	50%	206° C.	90%	216° C.
20%	193° C.	60%	208° C.	95%	220° C.
30%	200° C.	70%	210° C.		

Floto—A Steam Distilled Pine Oil

Floto is a lower grade oil than Remoh. This oil seems to be especially adapted to silver ores. It has also given very good results on many of the Mexican copper ores.

SPECIFICATIONS

Specific Gravity at 15° C.	0.905-0.910
Unpolymerized Residue, not over	15%
Refractive Index at 20° C. not under	1.475
Viscosity, Saybolt 100° F., very close to	39.0
Flash Point, Abel Closed Cup, not under	60° C.
Color	Dark Straw
Avg. Wgt. per Gallon (lbs.)	7.56

Distillation: (typical)

5%	180° C.	40%	196° C.	80%	210° C.
10%	185° C.	50%	200° C.	90%	215° C.
20%	190° C.	60%	206° C.	95%	220° C.
30%	193° C.	70%	208° C.		

Century—A Pine Product

Century is a specially constructed oil. It is used extensively on the copper ores of northern Arizona, as well as of northern California.

SPECIFICATIONS

Specific Gravity at 15° C.	0.937-0.942
Unpolymerized Residue, not over	8%
Refractive Index at 20° C., not under	1.50
Viscosity, Saybolt 100° F. very close to	42.5
Flash Point, Abel Closed Cup, not under	50° C.
Color	Black
Avg. Wgt. per Gallon (lbs.)	7.83

Distillation: (typical)

5%	175° C.	40%	195° C.	70%	330° C.
10%	180° C.	50%	215° C.	90%	350° C.
20%	185° C.	60%	218° C.	95%	375° C.
30%	190° C.				

Risor—A Crude Steam Distilled Oil

Risor is the crudest steam-distilled pine oil manufactured. It combines both collecting and frothing properties, but is generally used in a mixture containing about 35% Risor and 65% of a crude collecting oil. It is applicable to the lead ores of southeastern Missouri, as well as to many low-grade copper ores.

SPECIFICATIONS

Specific Gravity at 15° C.	0.959-0.963
Unpolymerized Residue not over	6%
Refractive Index at 20° C. not under	1.493
Viscosity, Saybolt 100° F. very close to	86.5
Flash Point, Abel Closed Cup, not under	55° C.
Color	Dark Brown
Avg. Wgt. per Gallon (lbs.)	8.00

Distillation (typical)

5%	203° C.	40%	214° C.	70%	228° C.
10%	206° C.	50%	215° C.	80%	238° C.
20%	210° C.	60%	220° C.	90%	250° C.
30%	212° C.				

Tarol—A Crude Pine Reagent

Hercules Tarol has been developed because of the demand for a very crude pine reagent. Hercules Tarol has given results similar to those generally obtained with destructive pine tar oil. The froth produced is made up of large, rather tough bubbles. This oil is especially adapted for Chalcopyrite, Chalcocite and Galena. In differential flotation and in cases where a subdued froth is essential, this pine oil gives satisfactory results.

SPECIFICATIONS

Specific Gravity at 15° C.	0.987-0.992
Unpolymerized Residue, not over	7%
Refractive Index at 20° C., not under	1.5
Viscosity, Saybolt 100° F. very close to	259
Flash Point, Abel Closed Cup, not under	68° C.
Color	Very Dark Brown
Avg. Wgt. Per Gallon (lbs.)	8.24

Distillation (typical)

5%	170° C.	40%	280° C.	70%	330° C.
10%	194° C.	50%	297° C.	80%	335° C.
20%	211° C.	60%	320° C.	90%	345° C.
30%	240° C.				

Prices

During 1920 and 1921 many companies abandoned the use of pine oil because of the very high prices. Steam-distilled pine oil sold in 1920 for as high as $2.97 a gallon due to its scarcity. Today the steam-distilled pine oils of the Hercules Powder Company are being offered to the trade at attractive prices which make their use not only possible but advisable instead of creosotes or chemical reagents. Buyers should, therefore, investigate thoroughly Hercules Pine Oils to determine their extraction yields as compared with other oils and reagents. It is significant that very small quantities of pine oil are needed to impart the required frothing quality to a flotation oil mixture. Steam-distilled pine oil usually constitutes not more than twenty-five per cent of the oil mixture, and in the majority of cases forms only ten per cent of the mixture. With pine oil consumption low and prices reasonable this insures a very low cost of pine oil per ton of ore treated. Recovery is usually materially helped by the use of pine oil.

Write for our booklets—A "Brief Survey of Flotation" and "Hercules Flotation Oils."

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The Roessler & Hasslacher Chemical Company

709-717 Sixth Ave., NEW YORK CITY

Works

PERTH AMBOY, N. J. ST. ALBANS, W. VA.
Niagara Electro Chemical Co., NIAGARA FALLS, N. Y.
Pacific R. & H. Chemical Corp., LOS ANGELES, CAL.
Cable Address: Jigda, New York

CYANEGG R&HCCo

Manufacturing and Importing Chemists

Product

SODIUM CYANIDE (Made in U. S. A.)

History and Use

Originally Cyanide was used principally for electroplating, photography and as an aid in the amalgamation process for the recovery of precious metal from ores. The consumption in the United States was not more than several hundred tons annually. With the introduction of the MacArthur-Forrest extraction process in the Transvaal in 1891, for the recovery of gold from tailings by the use of dilute cyanide solutions, now also applied to silver sulfide ores, the world's consumption of Cyanide has increased to many thousand tons per annum. It is estimated that 25% of the world's production of gold is now extracted with cyanide.

Early in the process the value of oxygen absorbed in the cyanide solution for accelerating the reaction was recognized. The equations generally accepted are:

GOLD $4Au + 8KCN + O_2 + 2H_2O = 4KAu(CN)_2 + 4KOH$

$4Au + 8NaCN + O_2 + 2H_2O = 4NaAu(CN)_2 + 4NaOH$

SILVER $4Ag + 8KCN + O_2 + 2H_2O = 4KAg(CN)_2 + 4KOH$

$4Ag + 8NaCN + O_2 + 2H_2O = 4NaAg(CN)_2 + 4NaOH$

Applicability

The Cyanide process is especially applicable to low-grade gold ores in which the gold occurs in a finely divided free or metallic state, or refractory ores to which the amalgamation process is not applicable, and to the more common, chloride and sub-sulfide, silver ores.

Advantages

Sodium Cyanide is more soluble in water than are the alkaline earth cyanides of barium, calcium and strontium; and it is also not so liable to decomposition in solution as these. It costs less than potassium cyanide.

The advantages of high-grade Sodium Cyanide are:

1. Labor-saving at the mines and convenience in handling.
2. Increased proportion of the active constituent, the cyanogen, and great extractive power.
3. Ready solubility.
4. Absence of insoluble and inert material and consequent avoidance of residues, making a separate dissolving operation unnecessary.
5. Minimum transportation cost, due to the high cyanogen content and the consequent lessened bulk.
6. Freedom from alkaline sulfides.

The Roessler & Hasslacher Chemical Company is today the only manufacturer of Sodium Cyanide in the United States.

In 1890 The Company began to manufacture Potassium Cyanide at Perth Amboy, N. J. Potassium Cyanide 98-99% KCN was first made by the old method of fusing Potassium Ferrocyanide; later Cyanide with addition of Sodium was made guaranteed to test equivalent to 98-99% KCN.

In 1902 the manufacture of synthetic Sodium Cyanide by the Castner process was taken up to replace the more expensive Potash Salts. At first a product of only 90% purity was obtained which has now been improved to the standard of 96-98% NaCN.

In 1916 the old method of designating the Sodium Cyanide in terms of Potassium Cyanide was dropped, though this designation of KCN equivalent to 128-130% still prevails in foreign countries. The present designation based on Sodium Cyanide content in comparison with the old method follows:

Old Designation	Cyanogen Content for both	New Designation
Sodium Cyanide 128-130%	51-52%	Sodium Cyanide 96-98%
Cyanide-Chloride Mixture 98-99%	39-40%	Cyanide-Chloride Mixture 73-76%

COMPARATIVE CYANIDE VALUES
(Theoretical)

NaCN (100%)		KCN (100%)	
Cyanogen (CN)	53.075%	Cyanogen (CN)	39.953%
Sodium (Na)	46.925%	Potassium (K)	60.047%
	100.00%		100.00%

1 lb. NaCN = 1⅛ lbs. KCN — 1 lb. KCN = ⅞ lb. NaCN

The standard grades are:

CYANEGG—Standard high grade Sodium Cyanide 96-98% NaCN with 51-52% cyanogen content. This is a clean white salt, cast in the shape of eggs, weighing uniformly about an ounce. It is packed in air-tight galvanized iron drums, holding net 100 and 200 lbs. (gross weight 110 and 220 lbs., respectively). Typical analysis of Cyanegg:

NaCN	97.00%
Na_2CO_3	1.07%
NaCNO	.35%
NaOH	1.58%
	100.00%

(Active cyanogen (CN) content: 51.47%
(Trace of Chlorine, not over 0.05%)

CYANOGRAN—96-98% NaCN with 51-52% cyanogen content, in granular form.

CYANIDE-CHLORIDE MIXTURE — 73-76% NaCN with 39-40% cyanogen content, equivalent to 98-100% KCN.

——Gold Medal Award, Panama-Pacific Exposition, San Francisco, 1915, for SODIUM CYANIDE——

OTHER CHEMICALS and materials used in the cyanide process, handled by The Roessler & Hasslacher Chemical Company are:

Zinc Sheets, Zinc Discs and Zinc Dust—For precipitation of gold and silver from solutions.

Soda Caustic and Potash Caustic—For neutralizing acidic ores.

Lead Acetate—For desulfurizing.

Zinc Chloride 98%, free from iron—For fireproofing and preserving timber.

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SECTION XXI

Assaying and Laboratory

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Becker, Christian, Inc.
Braun-Knecht-Heimann Co.
Mine & Smelter Supply Co., The
Thompson Balance Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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EQUIVALENTS OF WEIGHTS AND MEASURES*

LENGTH

1 mile = 5,280 feet = 1609.31 meters.
1 foot = 12 inches = 0.30479 meter.
1 inch = 25.3995 millimeters.
1 kilometer = 1,000 meters = 0.62138 mile = 3,281 feet.
1 meter = 100 centimeters = 3.280899 feet = 39.370791 inches.
1 centimeter = 10 millimeters = 0.393708 inch.
1 millimeter = 0.039371.

SURFACE

1 square yard = 9 square feet = 0.83610 square meter.
1 square foot = 144 square inches = 9.2900 square decimeters = 929.00 square centimeters.
1 square inch = 6.4514 square centimeters.
1 square meter = 100 square decimeters = 10764 square feet.
1 square decimeter = 100 square centimeters = 0.10764 square foot = 15.501 square inches.
1 square centimeter = 100 square millimeters = 0.15501 square inch.
1 square millimeter = 0.00155 square inch.

VOLUME

1 cubic yard = 27 cubic feet = 0.76451 cubic meter = 201.97 gallons.
1 cubic foot = 1728 cubic inches = 0.28315 cubic meter = 7.4805 gallons = 28.3153 liters = 29.922 quarts.
1 cubic inch = 0.017316 quart = 16.386 cubic centimeters.
1 gallon = 4 quarts = 0.13368 cubic foot = 231.0000 cubic inches = 3.7852 liters.
1 quart = 2 pints = 57.75 cubic inches = 0.94630 liters = 0946.30 cubic centimeters.
1 cubic meter = 1,000 liters = 1.3080 cubic yards = 35.317 cubic feet = 264.19 gallons.
1 liter, or 1 cubic decimeter = 1,000 cubic centimeters = 0.035317 cubic foot = 61.027 cubic inches = 0.26419 gallons = 1.0567 quarts.
1 cubic centimeter = 0.061027 cubic inch.

WEIGHT

1 ton = 2,000 pounds avoirdupois = 907.18 kilos. This is the ton used throughout this book unless otherwise specified.
1 long ton = 2,240 pounds avoirdupois = 1016.05 kilos.
1 metric ton = 1,000 kilos = 2204.62 pounds avoirdupois = 1.1023 tons = 0.98421 long ton.
1 pound avoirdupois = 16 ounces avoirdupois = 0.45359 kilo = 7,000 grains = 1.2153 pounds troy.
1 pound troy = 5760 grains = 0.82286 pound avoirdupois = 12 ounces troy = 0.37324 kilo.
1 ounce avoirdupois = 437.50 grains = 28.3495 grams = 0.91146 ounce troy.
1 ounce troy = 480 grains = 20 pennyweights = 31.1035 grams = 1.0971 ounces avoirdupois. The troy ounce and pound are used only for gold and silver and other precious metals.
1 grain = 64.799 milligrams.
1 kilo or kilogram = 1000 grams = 2.2046 pounds avoirdupois.
1 gram = 0.035274 ounce avoirdupois = 0.032151 ounce troy = 15.43235 grains = 1,000 milligrams.
1 milligram = 0.015432 grains.

MISCELLANEOUS MULTIPLIERS

Avoirdupois oz. per min. × 0.0450 = Tons per day.
Troy oz. per min. × 0.04937 = Tons per day.
Grams per m.n. × 0.00159 = Tons per day.
Tons per day × 630. = Grams per min.
Tons per day × 1.39 = Pounds Av. per min.
Troy oz. per ton × 0.00343 = % per ton.
% per ton × 292. = Troy oz. per ton.
Avoirdupois ounces × 0.9114 = Troy oz.
Troy ounces × 1.0971 = Avoirdupois oz.
Grams × 0.0321 = Troy oz.
Grams × 0.0353 = Avoirdupois oz.
Millimeters × 0.04 = inches.
Inches × 25. = millimeters.
1 Gram per Metric ton = 62c in gold.
1 Gram per Metric ton = 1.55 cents in silver (at 50c).
1 Dwt. of gold = $1.00.
1 Pound Avoirdupois = 453.60 grams.

*C. Herring. Table of Equivalents of Units of Measurement. From Metallurgical Bulletin General Engineering Co.

TEMPERATURE CONVERSION TABLES

By Albert Sauveur

—459.4 to 0			0 to 100				100 to 1000				1000 to 2000				2000 to 3000			
C.		F.	C.		F.		C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
—273	—459.4		—17.8	0	32	10.0	50	122.0	38	100	212	260	500	932	538	1000	1832	816	1500	2732	1093	2000	3632	1371	2500	4532
—268	—450		—17.2	1	33.8	10.6	51	123.8	43	110	230	266	510	950	543	1010	1850	821	1510	2750	1099	2010	3650	1377	2510	4550
—262	—440		—16.7	2	35.6	11.1	52	125.6	49	120	248	271	520	968	549	1020	1868	827	1520	2768	1104	2020	3668	1382	2520	4568
—257	—430		—16.1	3	37.4	11.7	53	127.4	54	130	266	277	530	986	554	1030	1886	832	1530	2786	1110	2030	3686	1388	2530	4586
—251	—420		—15.6	4	39.2	12.2	54	129.2	60	140	284	282	540	1004	560	1040	1904	838	1540	2804	1116	2040	3704	1393	2540	4604
—246	—410		—15.0	5	41.0	12.8	55	131.0	66	150	302	288	550	1022	566	1050	1922	843	1550	2822	1121	2050	3722	1399	2550	4622
—240	—400		—14.4	6	42.8	13.3	56	132.8	71	160	320	293	560	1040	571	1060	1940	849	1560	2840	1127	2060	3740	1404	2560	4640
—234	—390		—13.3	8	46.4	14.4	58	136.4	77	170	338	299	570	1058	577	1070	1958	854	1570	2858	1132	2070	3758	1410	2570	4658
—229	—380		—13.9	7	44.6	13.9	57	134.6	82	180	356	304	580	1076	582	1080	1976	860	1580	2876	1138	2080	3776	1416	2580	4676
—223	—370		—12.8	9	48.2	15.0	59	138.2	88	190	374	310	590	1094	588	1090	1994	866	1590	2894	1143	2090	3794	1421	2590	4694
—218	—360		—12.2	10	50.0	15.6	60	140.0	93	200	392	316	600	1112	593	1100	2012	871	1600	2912	1149	2100	3812	1427	2600	4712
—212	—350		—11.7	11	51.8	16.1	61	141.8	99	210	410	321	610	1130	599	1110	2030	877	1610	2930	1154	2110	3830	1432	2610	4730
—207	—340		—11.1	12	53.6	16.7	62	143.6	100	212	413	327	620	1148	604	1120	2048	882	1620	2948	1160	2120	3848	1438	2620	4748
—201	—330		—10.6	13	55.4	17.2	63	145.4	104	220	428	332	630	1166	610	1130	2066	888	1630	2966	1166	2130	3866	1443	2630	4766
—196	—320		—10.0	14	57.2	17.8	64	147.2	110	230	446	338	640	1184	616	1140	2084	893	1640	2984	1171	2140	3884	1449	2640	4784
—190	—310		— 9.44	15	59.0	18.3	65	149.0	116	240	464	343	650	1202	621	1150	2102	899	1650	3002	1177	2150	3902	1454	2650	4802
—184	—300		— 8.89	16	61.8	18.9	66	150.8	121	250	482	349	660	1220	627	1160	2120	904	1660	3020	1182	2160	3920	1460	2660	4820
—179	—290		— 8.33	17	63.6	19.4	67	152.6	127	260	500	354	670	1238	632	1170	2138	910	1670	3038	1188	2170	3938	1466	2670	4838
—173	—280		— 7.78	18	65.4	20.0	68	154.4	132	270	518	360	680	1256	638	1180	2156	916	1680	3056	1193	2180	3956	1471	2680	4856
—169	—273	—459.4	— 7.22	19	67.2	20.6	69	156.2	138	280	536	366	690	1274	643	1190	2174	921	1690	3074	1199	2190	3974	1477	2690	4874
—168	—270	—454	— 6.67	20	68.0	21.1	70	158.0	143	290	554	371	700	1292	649	1200	2192	927	1700	3092	1204	2200	3992	1482	2700	4892
—162	—260	—436	— 6.11	21	69.8	21.7	71	159.8	149	300	572	377	710	1310	654	1210	2210	932	1710	3110	1210	2210	4010	1488	2710	4910
—157	—250	—418	— 5.56	22	71.6	22.2	72	161.6	154	310	590	382	720	1328,	660	1220	2228	938	1720	3128	1216	2220	4028	1493	2720	4928
—151	—240	—400	— 5.00	23	73.4	22.8	73	163.4	160	320	608	388	730	1346	666	1230	2246	943	1730	3146	1221	2230	4046	1499	2730	4946
—146	—230	—382	— 4.44	24	75.2	23.3	74	165.2	166	330	626	393	740	1364	671	1240	2264	949	1740	3164	1227	2240	4064	1504	2740	4964
—140	—220	—364	— 3.89	25	77.0	23.9	75	167.0	171	340	644	399	750	1382	677	1250	2282	954	1750	3182	1232	2250	4082	1510	2750	4982
—134	—210	—346	— 3.33	26	78.8	24.4	76	168.8	177	350	662	404	760	1400	682	1260	2300	960	1760	3200	1238	2260	4100	1516	2760	5000
—129	—200	—328	— 2.78	27	80.6	25.0	77	170.6	182	360	680	410	770	1418	688	1270	2318	966	1770	3218	1243	2270	4118	1521	2770	5018
—123	—190	—310	— 2.22	28	82.4	25.6	78	172.4	188	370	698	416	780	1436	693	1280	2336	971	1780	3236	1249	2280	4136	1527	2780	5036
—118	—180	—292	— 1.67	29	84.2	26.1	79	174.2	193	380	716	421	790	1454	699	1290	2354	977	1790	3254	1254	2290	4154	1532	2790	5054
—112	—170	—274	— 1.11	30	86.0	26.7	80	176.0	199	390	734	427	800	1472	704	1300	2372	982	1800	3272	1260	2300	4172	1538	2800	5072
—107	—160	—256	— 0.56	31	87.8	27.2	81	177.8	204	400	752	432	810	1490	710	1310	2390	988	1810	3290	1266	2310	4190	1543	2810	5090
—101	—150	—238	0	32	89.6	27.8	82	179.6	210	410	770	438	820	1508	716	1320	2408	993	1820	3308	1271	2320	4208	1549	2820	5108
— 95.6	—140	—220	0.56	33	91.4	28.3	83	181.4	216	420	788	443	830	1526	721	1330	2426	999	1830	3326	1277	2330	4226	1554	2830	5126
— 90.0	—130	—202	1.11	34	93.2	28.9	84	183.2	221	430	806	449	840	1544	727	1340	2444	1004	1840	3344	1282	2340	4244	1560	2840	5144
— 84.4	—120	—184	1.67	35	95.0	29.4	85	185.0	227	440	824	454	850	1562	732	1350	2462	1010	1850	3362	1288	2350	4262	1566	2850	5162
— 78.9	—110	—166	2.22	36	96.8	30.0	86	186.8	232	450	842	460	860	1580	738	1360	2480	1016	1860	3380	1293	2360	4280	1571	2860	5180
— 73.3	—100	—148	2.78	37	98.6	30.6	87	188.6	238	460	860	466	870	1598	743	1370	2498	1021	1870	3398	1299	2370	4298	1577	2870	5198
— 67.8	— 90	—130	3.33	38	100.4	31.1	88	190.4	243	470	878	471	880	1616	749	1380	2516	1027	1880	3416	1304	2380	4316	1582	2880	5216
— 62.2	— 80	—112	3.89	39	102.2	31.7	89	192.2	249	480	896	477	890	1634	754	1390	2534	1032	1890	3434	1310	2390	4334	1588	2890	5234
— 56.7	— 70	— 94	4.44	40	104.0	32.2	90	194.0	254	490	914	482	900	1652	760	1400	2552	1038	1900	3452	1316	2400	4352	1593	2900	5252
— 51.1	— 60	— 76	5.00	41	105.8	32.8	91	195.8				488	910	1670	766	1410	2570	1043	1910	3470	1321	2410	4370	1599	2910	5270
— 45.6	— 50	— 58	5.56	42	107.6	33.3	92	197.6				493	920	1688	771	1420	2588	1049	1920	3488	1327	2420	4388	1604	2920	5288
— 40.0	— 40	— 40	6.11	43	109.4	33.9	93	199.4				499	930	1706	777	1430	2606	1054	1930	3506	1332	2430	4406	1610	2930	5306
— 34.4	— 30	— 22	6.67	44	111.2	34.4	94	201.2				504	940	1724	782	1440	2624	1060	1940	3524	1338	2440	4424	1616	2940	5324
— 28.9	— 20	— 4	7.22	45	113.0	35.0	95	203.0				510	950	1742	788	1450	2642	1066	1950	3542	1343	2450	4442	1621	2950	5342
— 23.3	— 10	14	7.78	46	114.8	35.6	96	204.8				516	960	1760	793	1460	2660	1071	1960	3560	1349	2460	4460	1627	2960	5360
— 17.8	0	32	8.33	47	116.6	36.1	97	206.6				521	970	1778	799	1470	2678	1077	1970	3578	1354	2470	4478	1632	2970	5378
			8.89	48	118.4	36.7	98	208.4				527	980	1796	804	1480	2696	1082	1980	3596	1360	2480	4496	1638	2980	5396
			9.44	49	120.2	37.2	99	210.2				532	990	1814	810	1490	2714	1088	1990	3614	1366	2490	4514	1643	2990	5414
						37.8	100	212.0				538	1000	1832				1093	2000	3632				1649	3000	5432

NOTE—The numbers in bold face type refer to the temperature either in degrees Centigrade or Fahrenheit which it is desired to convert into the other scale. If converting from Fahrenheit degrees to Centigrade degrees the equivalent temperature will be found in the left coumn, while if converting from degrees Centigrade to degrees Fahrenheit, the answer will be found in the column on the right. These tables are a revision of those by Sauveur & Boylston, metallurgical engineers, Cambridge, Mass. Copyright, 1920.

INTERPOLATION FACTORS

C.		F.	C.		F.
0.56	1	1.8	3.33	6	10.8
1.11	2	3.6	3.89	7	12.6
1.67	3	5.4	4.44	8	14.4
2.22	4	7.2	5.00	9	16.2
2.78	5	9.0	5.56	10	18.0

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ASSAY TON WEIGHTS

The Assay Ton Weights is a system made up from a comparison of the Avoirdupois, Troy and Gram Weights, and will be found extremely simple and useful, saving a vast amount of calculation and labor.

The Unit of the System is the Assay Ton (A. T.) = 29.166 grams. Its derivation will be seen at a glance.

1 lb. Avoirdupois = 7,000 Troy grains.

2,000 lbs. = 1 ton.

2,000 x 7,000 = 14,000,000 Troy grains, in one ton Avoirdupois.

480 Troy grains = 1 oz. Troy.

14,000,000 ÷ 480 = 29,166 Troy ozs. in 2,000 lbs. Avoirdupois.

There are 29,166 milligrams in one assay ton (A. T.); hence

2,000 lbs, is to 1 A. T., as 1 oz. Troy is to 1 milligram. Therefore, if 1 A. T. of ore assays 1 milligram of gold or silver, the ton contains 1 ounce Troy.

ASSAY CONVERSION TABLE

	Per Cent	Grams per Metric Ton (1000 kilos.)	Oz. Troy per Long Ton (2240 lbs.)	Oz. Troy per Metric Ton (2204.6 lb.)	Oz. Troy per Short Ton (2000 lb.)
1 per cent.....	1.0000	10,000.00	326.666	321.50700	291.666
1 gram per metric ton	0.0001	1.00	0.03266	0.03215	0.02916
1 oz. Troy per long ton	0.0030	30.6120	1.00	0.9842	0.89280
1 oz. Troy per metric ton	0.0031	31.10348	1.016	1.0	0.9071
1 oz. Troy per short ton	0.0034	34.28500	1.120	1.102	1.00
1 dollar per short ton (gold at $20.67 per oz..	0.00016	1.66000	0.054	0.053	0.048

PRINCIPAL ECONOMIC MINERALS*

Mineral	Specific Gravity	Hardness	COMPOSITION	
			Formula	Per Cent.
Antimony				
Stibnite	4.55	2	$Sb\ S^3$	Sb-71.4, S-28.6
Copper				
Atacamite—(Oxychloride)	3.75	3–3.5	$CuCl^2\ 3Cu(OH)^2$	Cu-59.5, Cl-16.6, OH-23.9
Azurite—(Blue Carbonate)	3.78	3.5–4.5	$2\ CuCO^3\ Cu(OH)^2$	Cu-55.3, O-13.9, CO^2-25.5, H^2O-5.2
Bornite—(Variegated, Peacock)	5.15	3	$2Cu^5FeS^4$ (or Cu^3FeS^3)	Cu-63.3, Fe-11.1, S-25.6
Brochantite—(Basic Sulphate)	3.9	3.5–4	$CuSO^4\ 3Cu(OH)^2$	Cu-66.2, SO^4-25.0, OH-8.8
Chalcocite—(Glance)	5.65	2.5–3	$Cu^2\ S$	Cu-79.9, S-20.1
Chalcopyrite—(Copper Pyrites)	4.2	3.5–4	$Cu\ Fe\ S^2$	Cu-34.6, Fe-30.4, S-35.0
Chrysocolla—(Silicate)	2.1	2–4	$Cu\ SiO^2\ 2H^2O$	Cu-36.1, SiO^2-34.3, 0-9.1, H^2O-20.5
Covellite—(Indigo)	4.6	1.5–2	CuS	Cu-66.5, S-33.5
Cuprite—(Red Oxide, Ruby)	6.0	3.5–4	Cu^2O	Cu-88.8, O-11.2
Enargite—(Sulph-Arsenate)	4.45	3	$Cu^3\ As\ S^4$	Cu-48.4, As-19.0, S-32.6
Malachite—(Green Carbonate)	4.0	3.5–4	$CuCO^3\ Cu(OH)^2$	Cu-57.5, O-14.5, CO^2-19.9, H^2O-8.1
Melaconite—(Black Oxide)	5.95	3	CuO	Cu-79.9, O-20.1
Tetrahedrite—(Gray Copper)	4.75	3–4.5	$4\ Cu^2S\ Sb$ (As, Fe, Pb, Zn, Ag) S^3	Cu-52.2, Sb-24.7, S-23.1
Iron				
Hematite—(Iron Oxide)	5.1	5.5–6.5	$Fe^2\ O^3$	Fe-69.9, O-30.1
Limonite—(Brown Hematite, Bog Ore)	3.6–4.0	5–5.5	$2\ Fe^2O^3\ 3H^2O$	Fe-59.8, O-25.7, H^2O-14.5
Magnetite—(Magnetic Oxide)	5.17	5.5–6.5	$Fe^3\ O^4$	Fe-72.4, O-27.6
Arsenopyrite—(Mispickel)	6.05	5.5–6	$Fe\ As\ S$	Fe-43.7, As-31.2, S-25.1
Marcasite—(White Pyrites)	4.9	6–6.5	$Fe\ S^2$	Fe-46.35, S-53.45
Pyrite—(Pyrites)	5.1			
Pyrrhotite—(Magnetic Pyrites)	4.65	3.5–4.5	$Fe^{11}\ S^{12}$	Fe-61.5, S-38.5
Siderite—(Spathic Iron)	3.85	3–4.5	$Fe\ CO^3$ (Mn, Ca, Mg)	
Lead				
Anglesite—(Sulphate)	6.2	2.75–3	$Pb\ SO^4$	Pb-68.3, S-10.6, O-21.1
Cerrussite—(Carbonate)	6.35	3–3.5	$Pb\ CO^3$	Pb-77.5, O-6.0, CO^2-16.5
Galena—(Sulphide)	7.45	2.5	$Pb\ S$	Pb-86.6, S-13.4
Manganese				
Pyrolusite—(Dioxide)	4.82	2–2.5	$Mn\ O^2$	Mn-63.2, O-36.8
Psilomelane	.....	.....	.....	.....
Rhodonite—(Silicate)	3.5	.....	$Mn\ Si\ O^2$	Mn-47.7, SiO^2-52.3
Rhodochrosite—(Carbonate)	3.5	.....	$Mn\ CO^3$	MnO-61.7, CO^2-38.3
Manganite	4.3	.....	$Mn^2\ O^3\ H^2O$	Mn-62.5, O-27.3, H^2O-10.2
Mercury				
Cinnabar—(Sulphide)	8.1	2–2.5	$Hg\ S$	Hg-86.2, S-13.8
Molybdenum				
Molybdenite—(Sulphide)	4.75	1–1.5	MoS^2	Mo-59.95, S-40.05
Wulfenite—(Lead Molybdate)	6.85	3	$Pb\ MoO^4$	Pb-56.4, Mo-26.2, O-17.4
Silver				
Argentite—(Glance)	7.3	2–2.5	Ag^2S	Ag-87.1, S-12.9
Cerargyrite—(Horn Silver)	5.55	1.5–2	$AgCl$	Ag-75.3, Cl-24.7
Proustite—(Light Red, Ruby Silver)..	5.6	2.5	$Ag^3As\ S^2$	Ag-65.4, As-15.2, S-19.4
Pyrargyrite—(Ruby Silver)	5.8	2–2.5	$Ag^3\ Sb\ S^3$	Ag-59.9, Sb-22.3, S-17.8
Stephanite—(Sulph-Antimonite)	6.2	2–2.5	$Ag^5\ Sb\ S^4$	Ag-68.5, Sb-15.3, S-16.3
Sylvanite—(Telluride)	8.1	.....	$Au\ Ag\ Te^2$	.....
Tin				
Cassiterite—(Tinstone)	6.95	6–7	$Sn\ O^2$	Sn-78.8, O-21.2
Tungsten				
Wolframite	7.35	5–5.5	$(Fe, Mn)\ WO^4$	(Fe-Mn)-30.9, W-51.3, O-17.8
Hubnerite	7.35	4.5	$Mn\ WO^4$	Mn-18.1, W-60.7, O-21.1
Scheelite	6.0	4.5–5	$Ca\ WO^4$	CaO-19.5, W-63.9, O-16.7
Zinc				
Calamine—(Hydrous Silicate)	3.45	4.5–5	$2\ ZnO\ SiO^2 + H^2O$	Zn-54.2, SiO^2-38.3, H^2O-7.5
Marmatite—(Iron Blende)	3.9–4.2	5	$(Zn\ Fe)\ S$	Zn ±42.7, Fe ±36.4, S-20.9
Smithsonite—(Carbonate)	4.35	5	$Zn\ CO^3$	Zn-52.1, C-9.6, O-38.3
Sphalerite—(Blende, Jack)	4.0	3.5–4	$Zn\ S$	Zn-67.1, S-32.9
Willemite—(Silicate)	4.0	5.5	$2\ ZnO,\ SiO^2$	Zn-58.6, SiO^2-41.4
Zincite—(Oxide)	5.5	4–4.5	ZnO	Zn-80.3, O-19.7
Graphite—(Black Lead)	2.15	.....	C	.....
Gangue				
Anhydrite—(Anhydrous Sulphate) ...	2.95	3–3.5	$Ca\ SO^4$	CaO-41.2, SO^3-58.8
Barite—(Baryta, Heavy Spar)	4.5	2.5–3.5	$Ba\ SO^4$	BaO-65.7, SO^3-34.3
Calcite—(Spar, "Lime," Limestone)...	2.72	3	$Ca\ CO^3$	CaO-56.0, CO^2-44.0
Dolomite—(Magnesium Limestone)...	2.85	3.5–4	$Ca\ Mg\ (CO^3)^2$	CaO-30.42, MgO-21.9, CO^2-47.7
Gypsum—(Hydrous Sulphate)	2.32	1.5–2	$Ca\ SO^4\ 2H^2O$	CaO-32.6, SO^3-46.5, H^2O-20.9
Magnesite—(Carbonate)	3.1	3–4.5	$Mg\ CO^3$	MgO-47.8, CO^2-52.2
Quartz—(Silica)	2.65	7	SiO^2	Si-46.9, O-53.1
Various Common Gangue Silicates....	2.5–3.5	.....	.....	.....

*From Metallurgical Bulletin of The General Engineering Company.

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FOREIGN COINS*

VALUES IN UNITED STATES CURRENCY

(Authorized by the Secretary of the Treasury of the United States, October 1, 1920)

All money in gold unless marked: (s) silver standard, or (gs) gold and silver standard.

Country	Coin Standard Monetary Unit	Value U. S. Gold Dollars 1920
North America		
Canada	Dollar	$1.0000
Cuba	Peso	1.0000
Haiti	Gourde	0.2500
Santa Domingo	Dollar	1.0000
New Foundland	Dollar	1.0000
Mexico	Peso	0.4985
Central America		
Costa Rica	Colon	0.4653
Guatemala	Peso [s]	0.6864
Honduras	Peso [s]	0.6864
British Honduras	Dollar	1.0000
Nicaragua	Cordoba	1.0000
Salvador	Colon [s]	0.5000
Panama	Balboa	1.0000
South America		
Argentina	Peso	0.9648
Bolivia	Boliviano	0.3893
Brazil	Milreis	0.5462
Chile	Peso	0.3650
Columbia	Dollar	0.9733
Ecuador	Sucre	0.4867
Paraguay	Peso	0.9648
Peru	Libra	4.8665
Uruguay	Peso	1.0342
Venezuela	Bolivar	0.1930
Europe		
Austria	Krone	0.2026
Belgium	Franc [gs]	0.1930
†Czecho-Slovakia	*Crown	*0.203
Denmark	Krone	0.2680
Finland	Markka	0.1930
France	Franc [gs]	0.1930
Germany	Mark	0.2382
Great Britain (Including British Colonies in Australia and Africa)	Pound Sterling	4.8665
Greece	Drachma [gs]	0.1930
Netherland [Holland]	Guilder [Florin]	0.4020
Italy	Lira [gs]	0.1930
†Jugo-Slavia	*Crown	*0.203
Norway	Krone	0.2680
†Poland	*Mark	*0.238
Portugal	Escudo	1.0805
Roumania	Leu	0.1930
Russia	Ruble	0.5146
Serbia	Dinar	0.1930
Spain	Peseta [gs]	0.1930
Sweden	Krona	0.2680
Switzerland	Franc	0.1930
Turkey	Piaster	0.0440
Africa		
Egypt	Pound	4.9431
Liberia	Dollar	1.0000
British Colonies	Pound Sterling	4.8665
Asia		
India	Rupee	0.3244
Indo-China	Piaster [s]	0.7413
Japan	Yen	0.4985
Persia	Achrefi [g]	0.0959
	Kran [s]	0.1264
Phillipines	Peso	0.50000
Siam	Tical	0.3709
Straits Settlements	Dollar	0.5678
	Tael [s]	1.0278
China	Tael [s]	to 1.1449
	Dollar [s]	0.7374
	Dollar [s]	to 0.7455

*From Metallurgical Bulletin of General Engineering Co.
†Values obtained from other sources than U. S. Treasury.
(Note—Chinese money varies in value between various ports.)

INTERNATIONAL ATOMIC WEIGHTS*

Symbol.	Atomic weight.	Symbol.	Atomic weight.
Aluminum .....Al	27.1	Mercury .....Hg	200.6
Antimony .....Sb	120.2	Molybdenum ....Mo	96.0
Argon .....A	39.88	Neodymium .....Nd	144.3
Arsenic .....As	74.96	Neon .....Ne	20.2
Barium .....Ba	137.37	Nickel .....Ni	58.68
Bismuth .....Bi	208.0	Nitrogen .....N	14.01
Boron .....B	11.0	Osmium .....Os	190.9
Bromide .....Br	79.92	Oxygen .....O	16.00
Cadmium .....Cd	112.40	Palladium .....Pd	106.7
Caesium .....Cs	132.81	Phosphorus .....P	31.04
Calcium .....Ca	40.07	Platinum .....Pt	195.2
Carbon C	12.005	Potassium .....K	39.10
Cerium .....Ce	140.25	Praseodymium ..Pr	140.9
Chlorine Cl	35.46	Radium .....Ra	226.0
Chromium .....Cr	52.0	Rhodium .....Rh	102.9
Cobalt .....Co	58.97	Rubidium .....Rb	85.45
Columbium ....Cb	93.1	Ruthenium .....Ru	101.7
Copper .....Cu	63.57	Samarium .....Sa	150.4
Dysporosium ..Dy	162.5	Scandium .....Sc	44.1
Erbium .....Er	167.7	Selenium .....Se	79.2
Europium .....Eu	152.0	Silicon .....Si	28.3
Fluorine .....F	19.0	Silver .....Ag	107.88
Gadolinium ....Gd	157.3	Sodium .....Na	23.00
Gallium .....Ga	69.9	Strontium .....Sr	87.63
Germanium ....Ge	72.5	Sulphur .....S	32.06
Glucinum .....Gl	9.1	Tantalum .....Ta	181.5
Gold .....Au	197.2	Tellurium .....Te	127.5
Helium .....He	4.00	Terbium .....Tb	159.2
Holmium .....Ho	163.5	Thallium .....Tl	204.0
Hydrogen .....H	1.008	Thorium .....Th	232.4
Indium .....In	114.8	Thulium .....Tm	168.5
Iodine I	126.92	Tin .....Sn	118.7
Iridium .....Ir	193.1	Titanium .....Ti	48.1
Iron .....Fe	55.84	Tungsten .....W	184.0
Krypton .....Kr	82.92	Uranium .....U	238.2
Lanthanum ....La	139.0	Vanadium V	51.0
Lead .....Pb	207.20	Xeno .....Xe	130.2
Lithium Li	6.94	Ytterbium .....Yb	173.5
Lutecium .....Lu	175.0	Yttrium .....Yt	88.7
Manganese ....Mn	54.93	Zinc .....Zn	65.37
Magnesium ....Mg	24.32	Zirconium .....Zr	90.6

*U. S. Bureau of Mines Bull. 95.

ELECTROCHEMICAL SERIES OF THE ELEMENTS

Non-metals	Metals		
—	Osmium	Hydrogen	Magnesium
Fluorine	Rhodium	Lead	Calcium
Oxygen		Tin	Strontium
Chlorine	Iridium	Nickel	Barium
Bromine	Gold	Cobalt	Lithium
Iodine	Platinum	Iron	Sodium
Sulphur	Palladium	Hydrogen occluded by Iron	Potassium
Phosphorus	Silver		Rubilium
Selenium	Iron Carbide	Hydrogen	Caesium
Iron Oxides	Mercury	Cadmium	+
Nitrogen	Copper	Zinc	
Boron	Arsenic	Manganese	
Carbon	Bismuth	Chromium	
Silicon	Antimony	Aluminum	

TREATMENT RATES ON GOLD ORES

Rates (1922) charged by the Golden Cycle Mining & Reduction Co., of Colorado Springs, Col., for treating gold ores are given in the following table:

To and including $4.50 per ton value,	$2.00 per ton plus $1 freight.
Over $4.50 and including $8 per ton value,	$2.25 per ton plus $1 freight.
Over 8.00 and including 10 per ton value,	4.00 per ton f.o.b. mill.
Over 10.00 and including 15 per ton value,	5.25 per ton f.o.b. mill.
Over 15.00 and including 20 per ton value,	6.25 per ton f.o.b. mill.
Over 20.00 and including 25 per ton value,	6.60 per ton f.o.b. mill.
Over 25.00 and including 30 per ton value,	6.90 per ton f.o.b. mill.
Over 30.00 and including 40 per ton value,	7.50 per ton f.o.b. mill.
Over 40.00 and including 100 per ton value,	8.60 per ton f.o.b. mill.
Over 100.00 value per ton.	6.50 plus freight (graduated).

—Eng. & Mining Journal-Press.

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CHRISTIAN BECKER, INC.

THE TORSION BALANCE CO.

Main Office

92 Reade Street, NEW YORK

Factory: 147-153 Eighth Street, Jersey City, N. J.

BRANCH OFFICES

Chicago, Ill.—31 W. Lake Street

San Francisco, Cal.—49 California Street

Products

Balances—Analytical, Assay, Bullion, Jewelers, etc.

Scales—Laboratory, Pharmaceutical, Textile, Cream-Test, Grain, etc.

Weights—Metric, Avoirdupois, Troy.

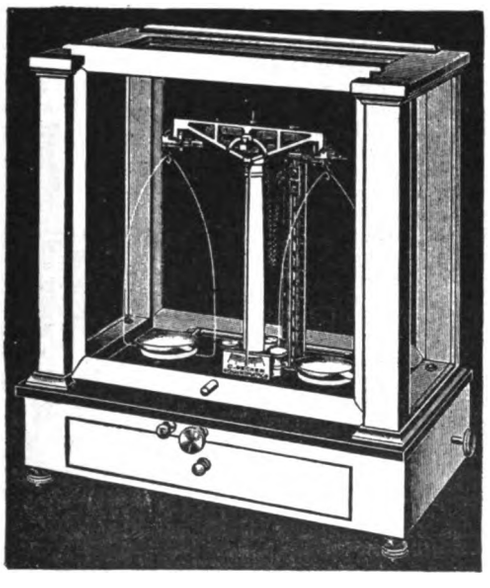
Analytical "Chainomatic" Balances

Riders and fractional weights up to 50 mg. eliminated.

Weighing in analytical chemistry completely revolutionized.

Thousands in use.

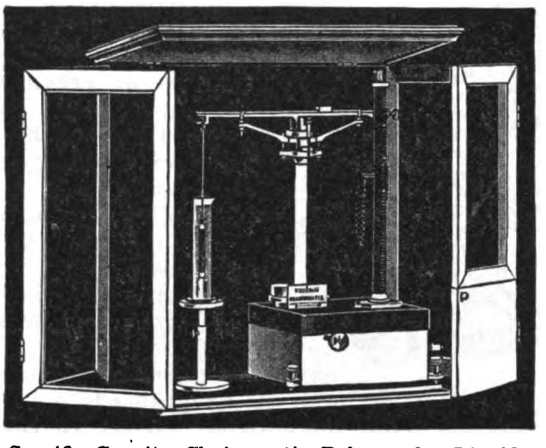
Endorsed by industrial chemists and educational workers everywhere.



Analytical Chainomatic Balance No. 8-A

Direct readings are taken from the graduated scale and vernier, in itself a great time-saving feature, and reducing errors to a minimum, when compared with the customary method of using small fractional weights, etc.

CHAINOMATIC
Trade-Mark



Specific Gravity Chainomatic Balance for Liquids

Specific Gravity Chainomatic Balance for Liquids

Graduated scale giving direct readings in specific gravity.

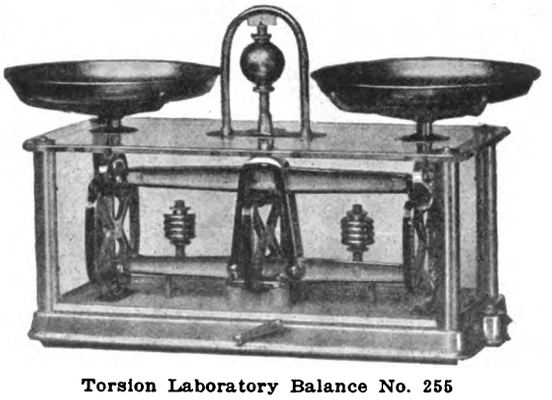
Simple, rapid, accurate, scientific.

Automatic in principle.

No weights or riders.

No. 100 ranging to 2.0000, to fourth decimal place.

Supplied to U. S. and Canadian Governments, industrial chemists, colleges, etc.



Torsion Laboratory Balance No. 255

Torsion Laboratory Balance No. 255

The accepted standard for laboratory work.

Capacity.....4½ kg.....(10 lb.)
Sensitiveness...1/15 gram.....(1 grain)
Pans.....8″ diameter

Equipped with or without graduated side beam, metric or avoirdupois.

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BRAUN--KNECHT--HEIMANN CO.

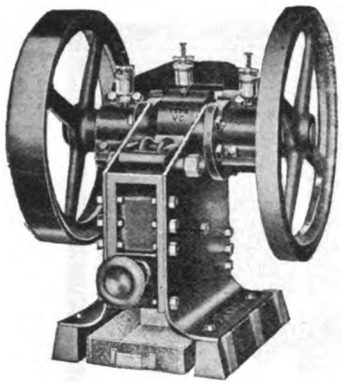
SAN FRANCISCO, CALIFORNIA, U. S. A.

Los Angeles House: THE BRAUN CORPORATION

Chemicals—Laboratory and Scientific Apparatus

Chipmunk Crusher

The Chipmunk Crusher is built for laboratory use, and, in its design, the features which a laboratory machine should possess, were given first consideration. The machine is strong, light, compact, easily cleaned, and there are no niches or crevices to entrap bits of material that might endanger accuracy. It possesses a simple, easily manipulated, adjustment. The downward and rapid motion of the movable jaw impells discharge of the products, and renders the machine adaptable to a variety of materials from the hardest quartz to coal or clay. Steel frame and long bronze bushings.

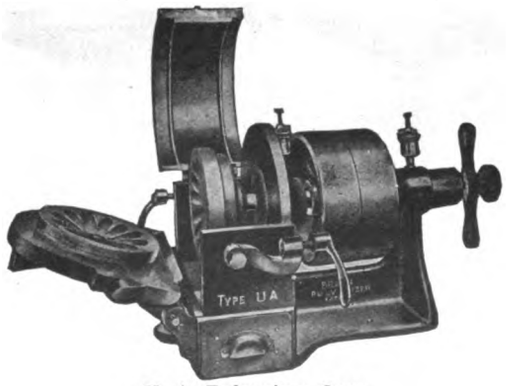


Chipmunk Crusher

Type V C 14, capacity 300 to 400 lbs. per hour.
R. P. M. 400, T. & L. pulleys.
Jaws 6"x3", opening 2¼"x3".
Shipping weight 270 lbs.
Price, f. o. b. San Francisco or Los Angeles, $110.00.
Larger size W C 18, capacity 1000 lbs. per hour, $190.00.

Braun U. A. Pulverizer

The Braun U. A. Pulverizer is designed to meet the requirements for grinding material to any desired mesh in metallurgical and testing laboratories, and will be found in general use throughout the world. The type U. A. is the latest improved machine, embodying all of those features that 20 years of application have demonstrated useful—not least among which is the removable, renewable



U. A. Pulverizer Open

babbitted bushings, obviating the necessity of having to perform the delicate job of babbitting in the field. Note the adjustment lock in the illustration—this **really locks** the adjustment. The grinding plates themselves are easily renewed, without waste, and are made of a steel alloy developed after much painstaking research—they are tough, uniform, and can be dressed with edged tools. Of course the machine is compact and easily cleaned.

Capacity 1 lb. per minute to 80 mesh.
R. P. M. 800 to 1000.
Grinding plates 8" diameter.
Shipping weight 275 lbs.
Dimension of case ready for shipment 20"x21"x28".
Price, f. o. b. San Francisco or Los Angeles, $135.00.

Rotary Flame Furnace

The illustration shows the complete arrangement of the Rotary Flame Furnace, with Cary Gasoline Burner and lead to pressure tank. This outfit has been found thoroughly satisfactory where both melting and cupelling is to be done in one simple and complete unit. The muffle gases and fumes are discharged into the flue, and the construction is such as to exclude from the muffle all reducing gases from the combustion chamber.

Rotary Flame Furnace

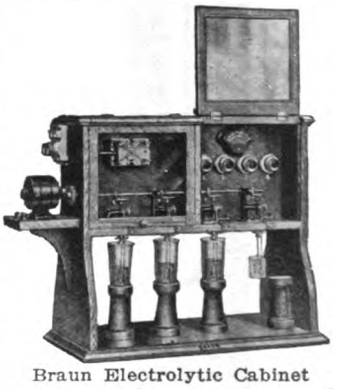
Built in 3 sizes, taking 6, 8 and 10 of the 20-gram crucibles.

Outfit No.	401	411	421
Shipping weight, lbs.	430	340	310
Price, complete with furnace, tank, burner, stand and fittings	$110.50	$101.50	$93.00

The Braun Electrolytic Outfit

The Braun Electrolytic Outfit for lead and copper assays is equipped with one motor to which a line shaft is attached and each unit is driven by a special friction device enabling the operator to use either one, two, three or more units at one time. The current through each unit is controlled by the individual switches. Revolving anodes and gauze cathodes are used. Direct current is necessary.

The Braun Electrolytic Outfit is the most modern and efficient apparatus for electrolytic determinations. The Cabinets are made in any number of units from two to six.



Braun Electrolytic Cabinet

Units	2	4	6
Price, without Platinum Electrodes	$175.00	$200.00	$225.00

Approximate weight of electrodes (furnished at market price of platinum):
Anodes...4.50 grams Cathodes...9.50 grams

Calmix Cupels

Calmix Cupels have virtually supplanted the hand made article in the modern assay office. Calmix are not only cheaper, they give more accurate and uniform results. Made in all sizes—Used generally throughout the world. Samples Sent Free.

Calmix Cupels

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THE MINE & SMELTER SUPPLY CO.

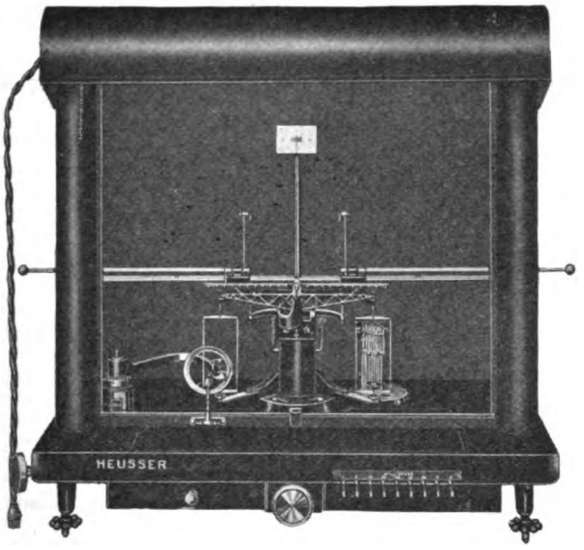
DENVER SALT LAKE CITY EL PASO

42 BROADWAY, NEW YORK MILLS BUILDING, SAN FRANCISCO

Outfitters For the Mine, Mill and Laboratory

HEUSSER BALANCES

Button and analytical balances characterized by high sensitivity, stability, rapidity, ease of operation, beauty, strength, and long life.



Patented Features Standard In Heusser Balances

1. The enduring, warp-proof, all-metal casing, which prolongs the instrument's life and protects it from extraneous influences.

2. The perfectly designed beam, a single piece of specially prepared brass, of uniform density, insuring constant dependability, combining maximum strength with minimum weight and bulk.

3. The bearings, of selected carnelian agate, a knife-blade edge upon a perfectly smooth flat stone.

4. The base and releasing mechanism, a compact unit of unique simplicity and efficiency.

Patented Features In Certain Heusser Models

5. The multiple-weight attachment, which handles weights mechanically, changes them without arresting the balance and saves at least half of the operator's time.

6. The mechanical pan-extractor, which deposits and removes buttons without recourse to the casing door.

These devices preclude the entrance of error-producing dust and air-currents by eliminating the use of the door.

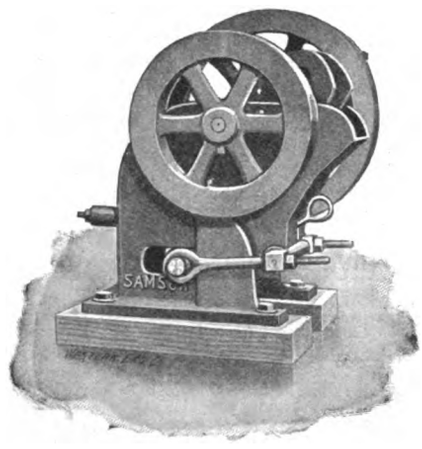
7. The illuminator, which insures perfect light under all conditions and can be attached to all models.

Bulletin No. 65 sent on request.

SAMSON CRUSHER

(Primary Laboratory Crusher)

The Samson Laboratory Crusher combines simplicity, strength, durability and economy of operation. It has a surprisingly large capacity and

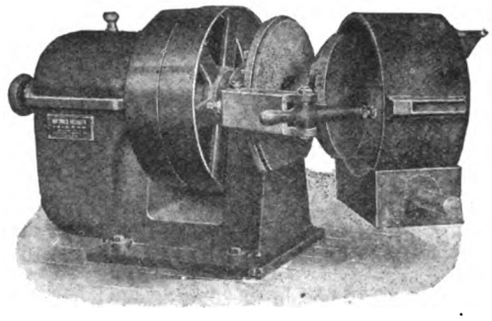


will unerringly crush to a uniform size. It cannot be choked by sticky material. No tools are required to open the crusher, and it can be opened and cleaned while running at full speed. It will crush more material to a finer mesh than any other laboratory crusher on the market.

McCOOL PULVERIZER

(Secondary Laboratory Crusher)

The McCool Pulverizer will reduce an eight-ounce sample to 100 mesh in 30 seconds. The grinding is done between discs so arranged as to prevent



grooving and unequal wear. The gears run encased in oil, virtually noiseless. The discs are the only wearing parts to replace, the cost is low and two minutes' time will suffice to change them. The McCool adequately fills a long-felt need. It has relegated the bucking-board to the oblivion of antiquities.

Catalog No. 54 (833 Pages) Sent On Request to Buyers of Laboratory Supplies.

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THOMPSON BALANCE CO.

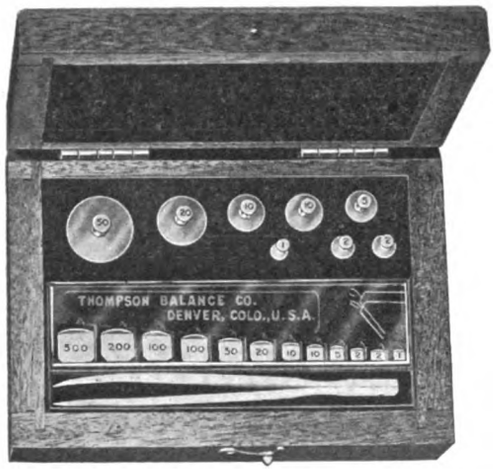
808 20th Street, DENVER, COLO.

High Grade Analytical Weights

High Grade Analytical Weights

These weights are for use in scientific and technical laboratories where accurate weighing is required. Gram weights are Tobin bronze lacquered or gold plated; fractionals from 500 mg to 50 mg are 22k gold or platinum as desired; 20 mg to 1 mg are aluminum. Riders may be 5, 6, 10 or 12 mgs as desired. Tweezers are carefully made of imitation ivory with fine points. The weights are adjusted within the tolerance prescribed by the Bureau of Standards for high grade analytical weights. Box is polished mahogany and has velvet lined pockets for the gram weights.

Order by number stating type desired.



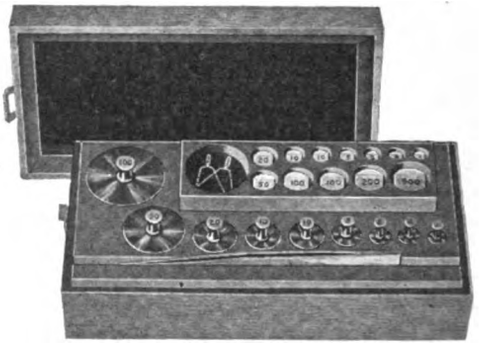
High Grade Analytical Weights

Cat. No.		Type LG Lacquered with Gold Frac.	Type GG Gold Plated with Gold Frac.	Type LP Lacquered with Plat. Frac.	Type GP Gold Plated with Plat. Frac.
40	20 g to 10 mg 2 Riders	$18.60	$21.70	$22.30	$25.40
41	20 g to 5 mg 2 Riders	19.10	22.20	22.80	25.90
42	20 g to 1 mg 2 Riders	20.60	23.70	24.30	27.40
43	50 g to 10 mg 2 Riders	20.40	24.30	24.10	28.00
44	50 g to 5 mg 2 Riders	20.90	24.80	24.60	28.50
45	50 g to 1 mg 2 Riders	22.40	26.30	26.10	30.00
46	100 g to 10 mg 2 Riders	23.20	27.90	26.90	31.60
47	100 g to 5 mg 2 Riders	23.70	28.40	27.40	32.10
48	100 g to 1 mg 2 Riders	25.20	29.90	28.90	33.60
49	200 g to 10 mg 2 Riders	28.90	35.30	32.60	39.00
50	200 g to 5 mg 2 Riders	29.40	35.80	33.10	39.50
51	200 g to 1 mg 2 Riders	30.90	37.30	34.60	41.00

Good Quality Analytical Weights

Weights from 1 to 20 mgs are aluminum; from 50 to 500 mgs are 22k gold. Adjusted within the tolerance prescribed by the Bureau of Standards for class S weights.

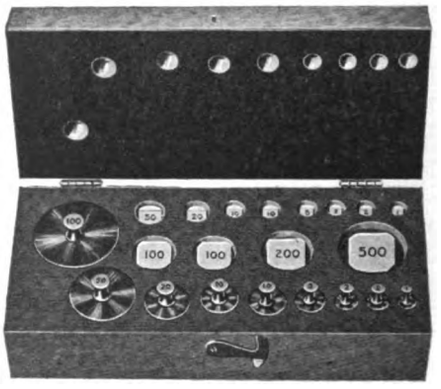
Polished mahogany box with metal tweezers.



Good Quality Analytical Weights with Gold and Aluminum Fractions

Weights from 1 to 20 mgs are aluminum, from 50 mg to 500 mg are 22k Gold.

Cat. No.	BRASS WEIGHTS LACQUERED		Cat. No.	BRASS WEIGHTS GOLD PLATED	
71	10 g to 1 mg 2 Riders	$12.00	76		$14.00
72	20 g to 1 mg 2 Riders	13.20	77		15.80
73	50 g to 1 mg 2 Riders	15.20	78		18.20
74	100 g to 1 mg 2 Riders	17.00	79		20.80
75	200 g to 1 mg 2 Riders	24.50	80		30.00



Medium Grade Analytical Weights
Brass Lacquered with All Fractions Aluminum

85	10 grams to 1 mg	$ 8.30
86	20 grams to 1 mg	9.30
87	50 grams to 1 mg	10.60
88	100 grams to 1 mg	12.40

Write us for prices on Assay Analytical and Pulp Balances. Our Multiple Rider Attachment for Assay Balances has only one moving part. It is the only practical device for handling weights from outside the balance case.

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SECTION XXII

Safety First, Sanitation and Welfare

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Channon, James H. Mfg. Co.
Durand Steel Locker Co.
Goodrich, B. F. Rubber Co., The
Howe Fire Apparatus Co.
Hygienic Fibre Co.
Mine Safety Appliances Co.
Safety First Supply Co.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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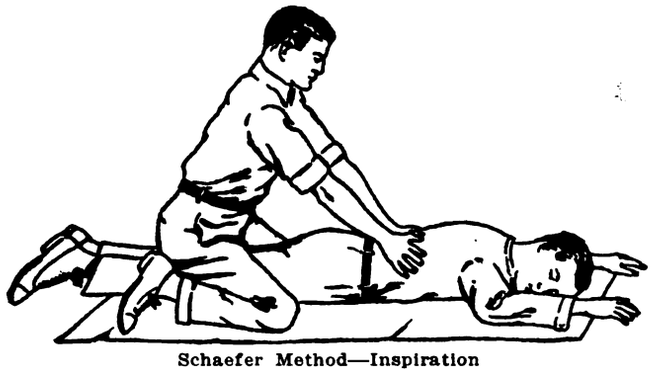
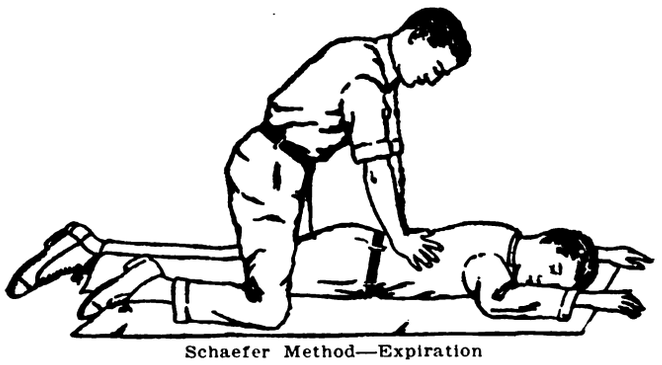
HELP IN CASE OF ACCIDENTS

Artificial Respiration by the Schaefer or Prone Method. Place the person on his abdomen; remove from his mouth all foreign bodies, such as false teeth, tobacco and gum; pull and keep the tongue forward; turn his head to one side and rest it on his forearm, so that the mouth and the nose will not come in contact with the ground, and extend the other arm forward. If the person is thin, prepare a pad of folded clothing, blanket or brattice cloth. Do not make this pad too thick. Do not wait to loosen the victim's clothing, but begin artificial respiration without delay. An assistant may remove all tight clothing from the victim's neck, chest and waist; blankets, hot-water bottles, safety lamps or hot bricks well wrapped in paper or cloth should be placed about the person by an assistant.



Schaefer Method—Inspiration

Kneel, straddling the person's thighs, and facing his head, rest the palm of your hands on his loins—on the muscles of the small of his back—with your thumbs nearly touching each other and your fingers spread over his lowest ribs; with arms held straight swing forward slowly so that the weight of your



Schaefer Method—Expiration

body is gradually brought to bear on the person. This operation, which should take three to four seconds, must not be violent, lest the internal organs be injured. The lower part of the chest and also the abdomen are thus compressed and air is forced out of the lungs. Now, immediately swing back slowly so as to reduce the pressure, but leave your hands in place, thus returning to the original starting position. Through their elasticity the patient's chest walls expand and his lungs are thus supplied with fresh air. After two seconds swing forward again and repeat deliberately, 16 to 18 times a minute, the double movement of compressing and releasing —causing a complete respiration in about four seconds. If a watch or clock is not available, follow the natural rate of your own deep breathing, swinging forward with each expiration and backward with each inspiration.

Continue artificial respiration, if necessary, for at least three hours without interruption until natural breathing his been restored or until a physician arrives. Even after natural breathing begins, carefully watch that it continues. If it stops, start artificial respiration again.

Do not give any liquids whatever by mouth until the person is fully conscious, when you may give slowly aromatic spirits of ammonia (a teaspoonful in half a glass of water), hot coffee, hot tea, or water.

Do not permit bystanders to crowd around. The assistant should not do anything that will interfere with the operator.

Resuscitating Devices. When the quantity of fresh air supplied to the patient by artificial respiration is small or insufficient, it is advisable that the manual method be supplemented by the release of pure oxygen from a container in proximity to the patient's nose or mouth, but avoiding creating any pressure that would cause injury or prevent free exhalations. When oxygen or oxygen and air are given, the manual treatment should not be stopped, but should continue as long as there is hope of reviving the patient.

Wounds. A wound may be defined as a break in the skin. Wounds may be divided into four kinds: incised, lacerated, contused and punctured. Incised wounds are produced by some sharp cutting instrument, such as a knife, a piece of glass, or a piece of sharp coal, slate or stone. The edges of the wound are smoothly divided without any bruising or tearing. Lacerated wounds present ragged edges and are the result of tearing the skin and tissues by blunt instruments or machinery. Contused wounds are those in which the skin is not divided, but is severely bruised. Such wounds are caused by heavy blunt instruments. Punctured wounds are caused by pointed instruments, such as needles, splinters, nails, or pieces of wire.

Bleeding is a flow of blood from an artery, vein or capillary. When bright red blood spurts from a wound, an artery has been cut. If the blood is red and oozes, it is from capillaries. When dark red blood is flowing in a steady stream, it is from a vein. When the blood is just oozing, there is no cause for hurry or alarm, but if it is spurting or flowing steadily, check it as quickly as possible, for the patient may soon be beyond aid by reason of the loss of blood. If there is severe bleeding, always check it first by the use of the tourniquet, not forgetting, however, the danger of leaving on a tourniquet too long.

The chief duty of a first-aid man in treating a wound is to prevent germs from getting into it. If pus germs do not enter, there will be no inflammation and the parts will heal quickly, but should such

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germs get in, blood poisoning is apt to follow. Rip or cut the clothing so that the injury may be seen. Do not touch the wound with your hand, clothing, or any instrument, and do not pour any drugs into it.

Electric Shock. Electricity causes shock by paralyzing the enrve centers that control breathing or by stopping the regular beat of the heart.

The symptoms of electric shock are sudden loss of consciousness, absence of respiration—which, if present, is slight and cannot be observed—weak pulse, and burns at the point of contact with the conductor of electricity. Always rescue the person as quickly as possible,being careful not to get in contact with the live wire or other conductor. Lose no time in looking for a switch to turn off the current. In the event that there is no switch near, take a drill, mine auger,bar, or piece of wire and throw it quickly across the trolley and the rail, taking particular care to release your hold of the instrument before it touches the live wire. By so doing, the circuit breaker in the power house will be thrown out and the current cut off. Leave the auger or other instrument across the wire, so that the circuit breaker will be thrown out continuously. Such action may cause injury to other working parts of the mine, but when a human life is at stake all the wires should be cut if necessary. A dry long-handled shovel will be of service in removing the patient from the wire.

If no wire, drill, or other instrument long enough to reach from the wire to the rail, is at hand, one may proceed to remove the victim from the live wire, but first get a dry board or piece of thick paper and put it under your feet, and protect the hand you use with your cap, coat, or any dry, non-conducting material, so as not to make a circuit. If possible use one hand only, placing the other behind you. If both hands are used to remove the person from the wire, make sure that both your hands and your feet are well insulated so that you will not be caught in the same contact. Another way is to take your belt, handkerchief, coat, or piece of dry rope and loop it over the victim's foot or head if he is lying on the wire, and thus pull him off. If an axe is near at hand, use it to cut the wire, but first make sure that the handle is dry, or wrap it with a coat or other dry and non-conducting material. Or you may use a dry board, dry cloth, or dry rope to pull the wire away from the patient.

After the person has been taken from the wire turn him over on his face, remove all foreign bodies from his mouth, such as false teeth, tobacco or gum, pull and keep the tongue forward, turn his head to one side, resting it on his forearm so that his mouth and nose will not come in contact with the ground, and extend his other arm forward. Start the Schaefer method of artificial respiration without delay.

Suffocation. A victim of suffocation or asphyxiation becomes unconscious, his lips and ear lobes become blue, his pulse and breathing stop, and his pupils become dilated. Where suffocation has been caused by gases, due care should be taken by the rescuer to protect himself. Unless the air where the victim is found is good, immediately get the person to pure air and perform the Schaefer method of artificial respiration.

Sprains. The injured joint should be elevated and placed at absolute rest, as often a sprain is accompanied by a fracture. Apply hot or cold towels over the injury several times.

Drowning. The most important essential after rescuing a drowning person is to get the water out of his lungs and stomach. Rolling him on a barrel is desirable, but as a rule a barrel is not available. As a substitute, have one man get on his hands and knees, so that the victim can be placed over the kneeling man's back, or, if you are alone with the victim, place and lock your hands underneath the patient's stomach and lift him several times, thus bending his body and allowing the water to flow out of his mouth Later resort to artificial respiration. Usually after a person has been immersed in water for five minutes life is extinct. There have been victims that have been revived after two hours of artificial respiration.

Burns or Scalds. Remove all loose clothing, but do not try to remove clothing that adheres to the skin—cut around it. For all cases of burns, the air should be excluded from the burnt surface as quickly as possible by the application of 0.5 to 1 per cent. picric acid gauze, moistened if possible with steam or clean water. In applying this gauze care must be taken not to bandage together open surfaces, such as fingers or toes, or the ear to side of head.

Frost Bites and Freezing. The parts most likely to be affected are the ones most exposed, such as the nose, ears, fingers and toes. The affected part is white and all sensation is lost. In the treatment rub the affected part with snow or cold water; then use warmer water gradually. Give hot coffee, hot tea or aromatic spirits of ammonia. The object is to bring the frozen part gradually to its normal temperature, as to immediately expose the frosted part to heat might result in gangrene or death of the part.

Snake Bite. Apply an improvised tourniquet just above the wound, between the wound and the heart, to stop circulation of the blood. Loosen the tourniquet every 20 minutes for one-half minute, to prevent gangrene. With the tip of a knife blade open the holes made by the snake's fangs, cutting lengthwise of the limb. Let blood run from the cut, at the same time rubbing the wound with the fingers to dislodge any of the poison that remains. Suck the wound. There is no danger in doing so provided you do not swallow the blood and you have no wound in or about the mouth. Wash wound with whiskey, if at hand. Rub into the wound some baking soda or permanganate of potash moistened with water.

Sunstroke. The treatment required is to reduce the temperature of the body as quickly as possible. To do this, remove the patient at once to a cool place and take off as much of the clothing as is necessary; apply ice or cold water to his head and body. To accomplish this effectively, place the patient in a cold bath and rub continuously to prevent shock. Keep up the cold applications until consciousness returns, then give the patient all the cool water he wants. If the skin becomes hot and dry again, renew the cold treatment. Give no stimulants.

Lightning. Dash cold water over stricken person.

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Fainting. Stretch out flat on back; allow fresh air and sprinkle with water. Keep head lower than rest of body.

Fire in One's Clothing. Don't run, especially downstairs or out in the air. Roll on carpet, or wrap in woolen rug or blanket. Keep the head in such position as not to inhale the flame.

Gasoline or Oil Fire. Gasoline or oil fire is best extinguished with flour, sand or earth, in the order named; water should not be used. If the gasoline be confined in small space, ammonia will smother it. Some users of gasoline find it well to hang a bottle containing about a gallon of ammonia from the top of the tank or room containing the gasoline, by a string or fusible link, so that if the gasoline takes fire the bottle will fall and be broken, releasing the ammonia and promptly putting out the burning gasoline.

FIRST AID FOR POISONS

First. Send for a physician.

Second. Induce vomiting by tickling throat with feather or finger; drinking hot water or strong mustard and water. Swallow sweet oil or whites of eggs.

Acids are antidotes for **Alkalies** and vice versa.

SPECIAL POISONS AND ANTIDOTES

Acids (Muriatic, Oxalic, Acetic, Sulphuric (Oil of Vitrol), Nitric). **Treatment**—Soaps Suds, Magnesia, Lime Water.

Prussic Acid. Treatment—Ammonia in water; dash water in face.

Carbolic Acid. Treatment—Flour and water; mucilaginous drinks.

Alkalies (Potash, Lye, Hartshorn, Ammonia). Treatment.—Vinegar or lemon juice in water.

Arsenic (Rat Poison, Paris Green). Treatment—Milk, raw eggs, sweet oil, lime water, flour and water.

Bug Poison (Lead, Saltpeter, Corrosive Sublimate, Sugar of Lead, Blue Vitrol). Treatment—Whites of eggs, or milk in large doses.

Chloroform (Chloral, Ether). Treatment—Dash cold water on head and chest; artificial respiration.

Iodine (Antimony, Tartar Emetic). Treatment—Starch in water; astringent infusions; strong tea.

Mercury and Its Salts. Treatment—Whites of eggs; milk; mucilages.

Opium (Morphine, Laudanum, Paregoric, Soothing Powders or Syrups). Treatment—Strong coffee, hot bath; keep awake and moving at any cost.

Note—Much of this material has been taken from the small pocket edition, "Advanced First-Aid Instructions for Miners," issued by the Bureau of Mines in 1917, a copy of which should be in the possession of every one interested in the subject of first aid.

POISONOUS ACTION OF HYDROCYANIC ACID

The poisonous action seems to be chiefly paralysis of the nerve centers. Anything which will act as a stimulus to the nerves, such as inhaling chlorine or ammonia, will act as an antidote, although the products of the reaction in these cases are also strong poisons. These stimuli are especially helpful in the case of "gassing," and should be followed by quiet, plenty of fresh air and keeping the patient warm, giving internal stimulants if necessary. The symptoms produced by inhaling small quantities of hydrocyanic acid gas are headache, giddiness, a peculiar sensation at the back of the throat, and sometimes nausea. Long continual respiration of small quantities of hydrocyanic acid gas, as in cleaning up, may give rise to chronic affections of the heart and throat, and for this reason men should not be kept continuously on this class of work, but placed where they are not subject to the fumes.

ANTIDOTE FOR CYANIDE POISONING

The Committee of the Chemical, Metallurgical and Mining Society of South Africa, appointed to investigate cyanide poisoning, recommend as an antidote the following:

1. Thirty cc. of a 23% solution of ferrous sulphate.
2. Thirty cc. of a 5% solution of caustic potash.
3. Two grams of powdered oxide of magnesium (light).

In every cyanide room there should be kept three boxes labeled CYANIDE ANTIDOTE, each containing:

1. A metal receptacle to hold about a pint, and a spoon.
2. A blue hermetically sealed phial, containing 30 cc. of a 33% solution of ferrous sulphate.
3. A white phial, hermetically sealed, containing 30 cc. of caustic potash.
4. A packet of oxide of magnesium (light).

Preparation of Antidote—Quickly empty the contents of the blue phial, of the white phial and of the magnesia package into the metal recepacle, and stir well with the spoon. This should be done as rapidly as possible, as the patient's chance of life depends on promptness.

Administration of the Antidote—If the patient is conscious, make him swallow the mixture at once and lie down for a few minutes. If the patient is not conscious, place him on his back and pour the mixture down his throat in small quantities, if necessary pinching his nose in order to make him swallow.

Incite Vomiting—After the antidote has been given, try to make the patient vomit by tickling the back of his throat with a feather or with the finger, or give a tumblerful of warm water and mustard.

Note—It must always be kept in mind that promptness of action is the first essential, as the poison acts quicky.

The box of remedies should never be removed from its place, but always kept complete and ready for an emergency. It is advisable to keep the remedies in duplicate in case of the accidental breaking of a sealed bottle.

In all cases of cyanide poisoning medical aid should be summoned without delay.

In case of skin irritation known as "cyanide eczema" the best cure is the removal of patient from contact with the solutions and the use of zinc or similar ointments.

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FIRE PREVENTION AND FIGHTING IN METAL MINES*

Somewhat more than a year ago the writer collected some extensive notes on metal-mine fires and a paper on metal-mine fire prevention and fighting. A summary of these notes was hastily prepared, with the assistance of G. Chester Brown, chief mining engineer, Industrial Accident Commission for the National Safety Council meeting. This summary, which is admittedly incomplete, is submitted in the hope that it will evoke some discussion that may result in a reduction in metal-mine fire hazards, somewhere along the line. To accomplish such a reduction does not require the application of complicated scientific data. The use of just a little care, a small amount of thoughtfulness and a bit of common sense will work wonders.

Underground Fire Fighting

There may be some interest in a short list of conclusions of a rather general nature that were reached in connection with some recent mine-fire fighting operations. No effort has been made to cover the field; the items have been jotted down loosely, and very hastily, in the order in which they occurred to the writer. Originality is claimed for only a few of them.

1. Temperature readings and analyses of mine-air samples, systematically taken, are invaluable to effective metal-mine fire fighting and recovery operations. The analysis of the return-air samples frequently gives a surprisingly accurate indication of conditions existing underground.

2. Employees must be thoroughly trained in the use of mine rescue apparatus, because a relatively slight difference in the amount of training makes a vast difference in the amount of work they can perform under oxygen. In general, slender, wiry men make better apparatus men than those of heavy, more muscular physique, although there are frequent exceptions to any such general statement.

3. Surprisingly high temperatures, up to 165° F. or 170° F. can be endured for short periods by wearers of mine rescue apparatus if the air is dry, but lower temperatures, 135° to 140° F. are almost unbearable if the air is very moist.

4. There is likely to be an urgent need of mine rescue equipment and thoroughly trained men familiar with the mine workings at every timbered metal mine.

5. The choice of fresh-air bases, when performing mine rescue work, is very important, for it must be certain that the air is not contaminated by gases from the fire. If natural ventilation is depended upon, the air current must be watched with care to see that it does not reverse.

6. The strictest discipline is necessary to prevent men who are returning from the fire zone from removing their apparatus before they reach the fresh air base.

7. Mechanical ventilation greatly simplifies metal-mine fire fighting operations and increases the safety of the men engaged in the work.

8. The products of combustion from a fire diffuse with great facility through closely filled ground for distances that are surprising. This is true even when differences in atmospheric pressure are relatively slight between the burning workings and those that are not affected by flames. Bulkheads in filled ground are absolutely useless, therefore, for fire-fighting purposes, as a general rule.

9. It is advisable to have bulkheads continuously and frequently patrolled even though they have been recently completed and carefully inspected.

10. If moist clay can be secured in sacks (or dry clay sacked and moistened) one of the quickest methods of building a satisfactory bulkhead in a drift or cross cut is to put up a wall or brattice of 2 by 12-in. or 2 by 6-in. boards nailed to posts or stulls and fitted as closely as possible at the ends, then to nail two or more 3 by 3, or 4 by 4-in. strips on the outside and add another board wall, fastened to the strips, moist clay being tamped between the walls as the outside wall is put up. The outside wall should be calked carefully with clay, especially around the edge and at the top and bottom.

11. When bulkheading timber drifts or cross cuts, a tight seal rarely, if ever, can be made unless all lagging is cut and a section removed, and all loose rock and dirt taken down before the bulkhead is started.

12. Close observation of both candle and canary birds is necessary if men working without mine rescue apparatus in the fire zone are to be spared the nausea and excruciating headache of slight CO poisoning. If men working hard are using a bird to warn them of carbon monoxide, the bird should be kept moving enough to make it pant, otherwise men may be affected before the bird shows distress.

13. The resistance of individuals to low percentages of CO varies between relatively wide limits. Frequently more robust individuals with large lung capacities are the first to succumb.

14. Timber fires burn and spread more rapidly than coal fires and conversely die down and cool off more rapidly when the air supply is checked. They are extremely deceptive and likely to blaze up when it is thought that they have been extinguished.

*By H. M. Wolflin, Presented at the Mining Section of the National Safety Council, Boston meeting, Sept. 27-30, 1921.

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15. When the fresh-air supply is restricted, an underground fire tends to travel against the air current, even though the current may be coming from below; if the air is moving at higher velocities, so that the supply is more plentiful, the fire may travel both ways. If the draft is extremely strong, the fire will probably travel with it.

16. Reliable means of signalling from skip or cage should be maintained at all times during fire-fighting operations in shaft mines. The method of signalling becomes extremely important when it is necessary to ride skip or cage in irrespirable atmospheres.

17. The presence of carbon monoxide in the mine air indicates an active fire (except for the relatively small amounts of CO generated in blasting operations), but the absence of carbon monoxide is not a positive indication that the fire has been extinguished.

18. Finally, it is pointed out that effective organization of fire-fighting forces is of paramount importance. Men, equipment and supplies mean nothing, can accomplish nothing, without thorough organization and the strictest discipline. This is regarded as the most important of all the suggestions and observations.

Prevention and Protection

In connection with the broad problem of metal-mine fire prevention and protection, the following somewhat general observations and suggestions may be of passing interest:

1. All wooden headframes, wooden structures and supplies of inflammable materials near any mine entrance should be removed or replaced by fireproof structures. If this can not be done, at least such wooden structures should be made as nearly fireproof as possible by means of gunite or some other equally efficient method. All planked floors around the collar of the shaft or at the portal should be removed and non-inflammable construction substituted.

2. Mine timbers should not be piled in the immediate vicinity of the collar of the shaft or at the portal of an adit or a tunnel.

3. Proper storage of dynamite in fireproof places is essential. Boxes of dynamite should not be left near the collar of the shaft or at the portal of an adit or tunnel.

4. Removal of all accumulation of inflammable waste material and refuse from the mine or near the vicinity of the collar of the shaft is important.

5. Proper storage of gasoline or oil at an adequate distance from the mine entrance should receive attention.

6. If underground pump stations or hoist stations need support, steel and concrete or at least gunited timber should be used.

7. All oily waste should be removed promptly from the vicinity of pump or hoist stations and pending removal should be kept in metal receptacles carefully placed and protected.

8. Electrical apparatus, especially wiring and transformers, should be properly installed and carefully protected. All electrical equipment should be placed in fireproof stations.

9. The installing of adequate underground and surface fire-fighting equipment, and the organization of fire-fighting crews are worthy of the most active attention.

10. Fire drills on the surface and underground should be conducted frequently and thoroughly. Those commonly conducted underground are pitifully inadequate and generally come at such long intervals and involve so few men that they are almost worthless. How many men in the average metal mines have an adequate knowledge of the location of escapeways and fire-fighting equipment? How many receive intelligible instruction in these important items with sufficient frequency to retain it with any degree of accuracy?

11. "Second exits" or escapeways are generally intake airways. The best chance that men have when trapped in this way is to bulkhead themselves in dead-ends and wait for rescue. Frequently splitting the air in the ventilating current reduces this danger.

12. Every deep metal mine should be equipped with an efficient means of mechanical ventilation by which the air currents can be reversed quickly, if necessary; and every such mine in which several levels are being worked simultaneously should have its air circulation divided into a number of splits.

13. Some provision should be made to give danger signals or "all out" signals to underground men. Every metal mine should be equipped to introduce a stench into the compressed air lines in cases of emergency, and a supply of the stench-making material should be on hand at all times. Such arrangements are easily made and are not expensive, yet may be the means of saving many lives especially if all men are well drilled in their use.

14. Crews should be organized for effective between-shift inspections of timbered workings, shaft stations, airways, pump stations, etc.

15. Proper fire doors should be installed at strategic points to assist in the control of the ventilation.

16. The introduction of miners' electric cap lamps, and forbidding men to carry matches, flame-making devices, or smoking materials would be an important item in the reduction of underground fire hazards. Of course, if fuse is used for blasting, the men who split the fuse must be equipped with some type of flame-making device. These suggestions may be regarded as somewhat radical now, but they are feasible and the time will come when they will receive thoughtful consideration.

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Preservation of Natural Scenery and Attractiveness of Mining Camps*

Many mines are situated in the most beautiful part of the world, in regions it has taken countless ages of Nature's activity to bring to their present conditions. Would it not therefore be eminently desirable that those in charge should do all they can to preserve, and even to develop these natural beauties, so that natural aspects of great beauty may not become scenes of thoughtless devastation? The American Scenic and Historic Preservation Society earnestly suggests that this policy may be pursued.

Another consideration, and one of at least equal importance, is that the cabins and homes of the miners be made both attractive to the eye and comfortable as places of abode. Especially necessary in this connection are the preservation and the cultivation of trees in the immediate neighborhood of these dwellings, for if trees are ruthlessly destroyed a lifetime is often required to replace them. By the exercise of a little care in these respects it would be possible, almost without expense, to render the miners' lives more restful and pleasant, and this would assuredly serve to make them more contented and better citizens.

In addition to this care of tree life, it would be an easy matter to have little garden patches in the vicinity of the dwellings, and to provide the miners with the opportunity to cultivate these little gardens in part of their spare time. This also would serve as an elevating influence upon their lives, and would help them to resist the depressing effects of constant toil under hard conditions.

The writer has no wish to suggest the laying out of expensive parks, or, in other words, to cause additional expense; the only aim would be to remove unsightly and useless obstructions. It is true that where reduction works are started near the mine this often makes it impossible for anything to grow. Such really necessary obstacles would be accepted and counted with. But in most other cases it will be found that a regulation of operations will greatly aid in the development here advocated. One important consideration is that there be no planless scattering of the material derived from excavations. Instead of transporting it over roads running in a variety of directions, the roads could be made to converge at a certain point, where the rubble could be leveled out and made to afford a series of platforms, constituting splendid foundations for any projected buildings.

Finally, as to the miners' dwellings, we might suggest that if suitable prizes were offered for definite designs, the execution of which would not entail any greater cost than that of the poor structures now built, this would prove a helpful factor in the elevation of the standard of living. Indeed, with proper care and foresight, these more attractive cabins might be erected at even less expense than is required for those now put up.

*By George F. Kunz. Presented at February, 1922, meeting of A. I. M. & M. E.

RULES FOR DYNAMITE AND POWDER MAGAZINES

Explosives must be handled carefully.

Do not throw down boxes of explosives, nor drag them along the floor.

Do not open boxes of dynamite or powder kegs in or near the magazine.

Do not have in or about the magazine loose cartridges, open boxes of dynamite, or loose powder.

Do not make up primers in magazine.

Do not smoke, have matches, oil-burning lamps or lanterns, firearms or cartridges in or near the magazine. If artificial light be needed, use electric flashlight or electric lantern.

Do not store blasting caps or electric blasting caps in the magazine.

Store dynamite and black powder separately. Store dynamite boxes flat, top side up, grades and brands showing; store powder kegs on sides with seams down, or on ends, bungs down.

Powder kegs should be rolled over and contents shaken every two or three months.

Always use old stock first.

Keep magazine floor clean.

Keep the ground immediately around magazine clear of leaves, grass, trees, stumps, and debris, to prevent fire from reaching it.

Do not allow any shooting in the neighborhood of magazine.

Keep the door locked.

No unauthorized person should be admitted to magazine.

Do not keep any steel, or metallic tools or other implements, in the magazine.

See that good ventilation is maintained during all seasons of the year.

When repairs have to be made to interior of magazine, all stocks of explosives should be removed to safe distance and carefully protected from weather during progress of repairs. Before starting repairs in a black-powder magazine scrub floor with water. If dynamite has been stored in magazine, any stains on floor should be carefully scrubbed with solution consisting of ½ gal. water, 1 gal. denatured alcohol, ¼ gal. acetone, 1 lb. sodium sulphide (fused) or potassium sulphide.

Compiled from Bulletin 75, U. S. Bureau of Mines and Catalogs of Hercules and Du Pont Powder Companies.

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MINE SAFETY APPLIANCES CO.

Chamber of Commerce Building
PITTSBURGH, PA.

BRANCHES

CHICAGO
189 North Clark St.

DENVER
2320 Clermont St.

HUNTINGTON, W. VA.

LOS ANGELES
Chamber of Commerce Bldg.

NEW YORK
82 Fulton St.

PHILADELPHIA
2320 Clermont St.

PITTSBURG, KAS.
Commerce Bldg.

SAN FRANCISCO
268 Market St.

SEATTLE
505 Polson Bldg.

ST. LOUIS
907 Boatmen's Bank Bldg.

WILKES-BARRE, PA.
364 Wright St. (Kingston)

CANADA, Drummond, McCall & Co., Victoria Square, Montreal, P.Q.; Maritime Bldg., New Glasgow, N. S.

Safety Engineers

"EVERYTHING FOR MINE AND INDUSTRIAL SAFETY"

Being the pioneer, and today the largest exclusive safety appliance institution in the world, is the distinction that has been achieved by this Company.

Because it has been attained through real service, makes this prestige of even greater value to the customers than to the Company.

For nowhere else can be obtained the combined advantages of our Laboratories and Research Work, and the many original devices they have created; a most modern factory built and equipped throughout solely for the production of safety apparatus; the broad experience and training of men whose life work is devoted to safety; and above all, the M-S-A spirit to serve each customer to his own greatest advantage.

BURRELL GAS MASKS

One of the outstanding features of the Burrell series of gas masks is the variety of gases from which protection can be obtained. There is a type of mask adapted to every commercial need. The complete list will be sent on request, and our Service Department is always ready and willing to recommend the mask most suitable to your conditions.

Carbon Monoxide Masks

Special attention should be called to the CO-50 Carbon Monoxide and the CO-10 All-Service Masks. These will positively protect the worker from carbon monoxide and producer gas. They are more completely described on the following page.

Type GM Burrell Gas Mask With Case

Ammonia Masks

Every refrigerating plant should have available a Burrell Ammonia Mask. Repairs and maintenance can be taken care of immediately without danger to the worker as this mask will give absolute protection.

The Burrell Ammonia Mask has the official approval of the U. S. Bureau of Mines and that of many insurance companies. The list of approvals is constantly increasing and will be sent on request.

Hose Masks

It is sometimes desirable to conduct fresh air from outside to the face piece on the wearer, thereby avoiding the use of the purifying canister. Hose masks can be supplied for this purpose.

Mask in Position for Use

Exclusive Burrell Features

The face piece is the latest improved Army model, Kops patent. It is the most comfortable face piece made. The mask fits the face perfectly, has less dead air space, and permits a wider vision through the eyepieces.

Eye pieces are stamped in, giving no chance for leakage.

Head elastics are replaceable.

A wide range of protection, covering every noxious gas which will be encountered, including **carbon monoxide.**

A carrying case made of three-ply gum-veneer, like the best trunks. It is very strong and will withstand considerable punishment.

M-S-A laboratories and **engineering facilities** are always available for investigating your protection problems. Our experience in this field assures you the proper type of mask to meet your particular conditions.

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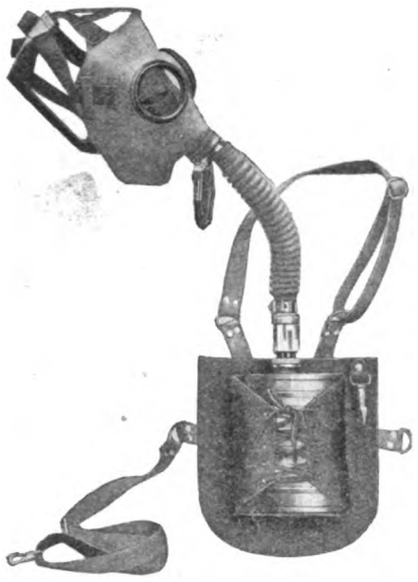
Burrell Carbon Monoxide Gas Masks for Fire Fighting, Shot-Firers, Etc.



Burrell All-Service Gas Mask No. CO-10
Complete Mask Includes Case and One Extra Canister
Weight, Mask Only, 5¾ Pounds
Shipping Weight, With Case, 21 Pounds

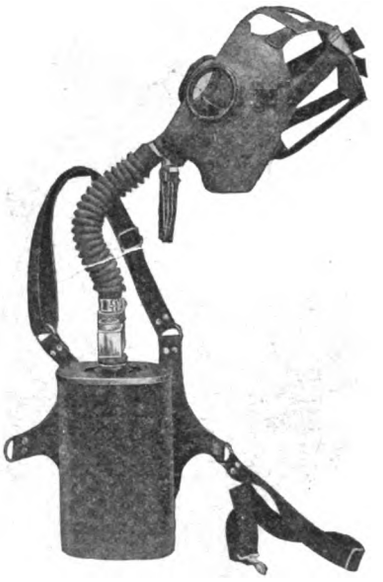
All-Service Mask No. CO-10

This mask gives complete protection against any noxious gases either alone or in combination, including carbon monoxide, illuminating gas, fumes, smoke and dust, and is used in a wide variety of operations, including **coal mines, fire departments, chemical and metallurgical plants,** and in other places where combinations of gases and smoke, including carbon monoxide and illuminating gas are present. This mask operates exactly as other types of mask and includes a Timer for telling when the canister is exhausted.

Carbon Monoxide Mask No. CO-50

This mask is used where carbon monoxide only is encountered. It includes a Timer for telling when the canister is exhausted.

It is in extensive use around blast furnaces, gas producers, etc., and will positively protect against carbon monoxide gas.



Burrell Carbon Monoxide Mask No. CO-50 Complete Mask Includes Case and One Extra Canister
Weight, Mask Only, 5¾ Pounds
Shipping Weight, With Case, 20 Lbs.

M-S-A CARBON MONOXIDE DETECTOR

A Practical, Simple and Positive Instrument for Quickly Detecting the Presence and Amount of Carbon Monoxide Gas. It gives an accurate indication of when protection from this gas is required.

Uses for The M-S-A Carbon Monoxide Detector

Coal and Metal Mines. The presence of carbon monoxide in a mine always indicates fire. Where fire is suspected a few tests with the Detector will prove the presence or absence of this gas. Fire Bosses or other inspectors may sample the return air courses for carbon monoxide, particularly where seams are mined on different levels. This may be done on early morning rounds, during the shift, and particularly on fire inspection before Sundays or other idle days.

The M-S-A Detector gives a fire fighting or mine rescue squad a positive means of determining the carbon monoxide condition at any time and place. Guess work is eliminated. The Detector gives a quick and sure test.

Sensitiveness of the M-S-A Carbon Monoxide Detector

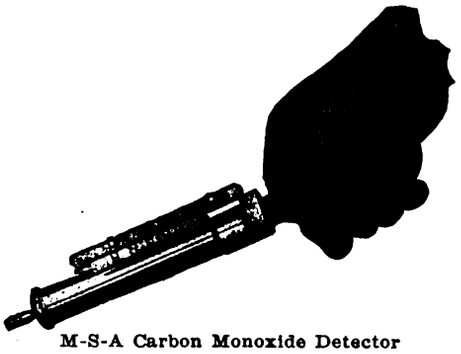
The M-S-A Carbon Monoxide Detector is extremely sensitive and will detect percentages of gas far below the immediately dangerous point. This is of great value because persons are frequently affected by continued exposure to small amounts.

While canaries have proved valuable in detecting carbon monoxide, they are not entirely reliable in smaller percentages.

About ten seconds are required for a test with the M-S-A Carbon Monoxide Detector and the results are sure.

The Color Scale is calibrated from .05% (5-100) to 1%.

Bulletin No. 60, fully describing this device, sent on request.



M-S-A Carbon Monoxide Detector

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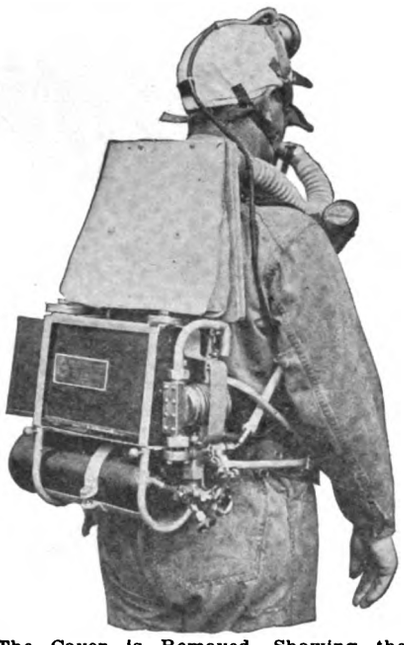
Gibbs Oxygen Apparatus

Gibbs Oxygen Breathing Apparatus

Self-Contained Oxygen Breathing Apparatus (sometimes called "helmets" or "rescue apparatus") is a device that enables a man to work in an atmosphere devoid of oxygen.



The Cover is Removed, Showing the Construction of the Gibbs

The Gibbs is an apparatus that provides a constant supply of oxygen to replace the oxygen consumed in sustaining life. It also carries an absorber to render harmless the carbon-dioxide exhaled from the lungs.

For fire fighting and rescue work the Gibbs is indispensable. It enables the wearer to breathe in comfort and safety in any atmosphere. The oxygen is supplied automatically, and whether the man is under violent exertion or at complete rest just the proper amount is supplied to meet the needs of the moment.

The Gibbs Apparatus has been approved by the U. S. Bureau of Mines, and is in use in their Rescue Cars and Stations. It has been adopted by the big coal and metal mines—in all, more than 1200 Gibbs Apparatus have been installed.

The Gibbs Refillable Cartridge Regenerator

A "permissible" container for CARDOXIDE, the chemical used for absorbing carbon dioxide exhaled by the wearer of breathing apparatus.

CARDOXIDE absorbs more CO_2 than straight caustic, with less heating; can be handled freely without burning the skin or clothing; does not become soft and clog up air passages; keeps indefinitely in storage.

Regenerator Used With Gibbs Oxygen Apparatus

REGENERATOR is made of sheet steel thoroughly coated and fitted with brass connections; divided into two compartments, into each of which is placed two pounds of CARDOXIDE. Full charge is four pounds. After a full working period in apparatus, the used chemical is poured out and the container refilled with fresh CARDOXIDE. When empty regenerator may be readily tested for air tightness, and the chemical carefully examined as it is filled. This makes for additional safety. The better absorption value of CARDOXIDE and the method of passing the air through the REGENERATOR secure the very highest efficiency,—the merest traces of CO_2 being found in the inspired air. The regenerator being refillable, only the CARDOXIDE is used up. The cost of the container is saved. The cost of a full working period in the apparatus, using the Gibbs Refillable Regenerator and Cardoxide, is less than half the cost of a sealed manufactured regenerator.

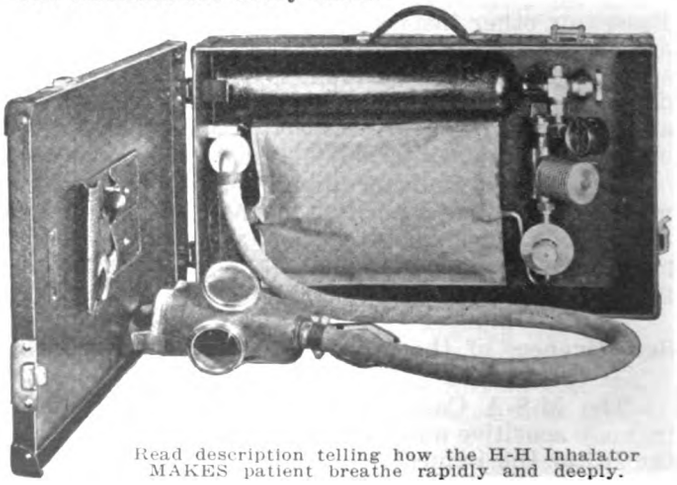
Refillable Regenerator and a supply of Cardoxide packed in 4-lb. cans sent on your request for trial.

THE H-H INHALATOR—A New Principle

The patient breathes a mixture of Oxygen plus Carbon Dioxide, either naturally or induced by the Schaefer Method of Artificial Respiration. Immediately the involuntary muscles respond, breathing becomes deep and regular. A maximum exchange is produced, Oxygen is absorbed, dangerous gases expelled, recovery is rapid, effects minimized.

Complete in case with all needed accessories. An essential for every mine.

Showing Method of Operating H-H Inhalator With Manual Method of Resuscitation



Read description telling how the H-H Inhalator MAKES patient breathe rapidly and deeply.

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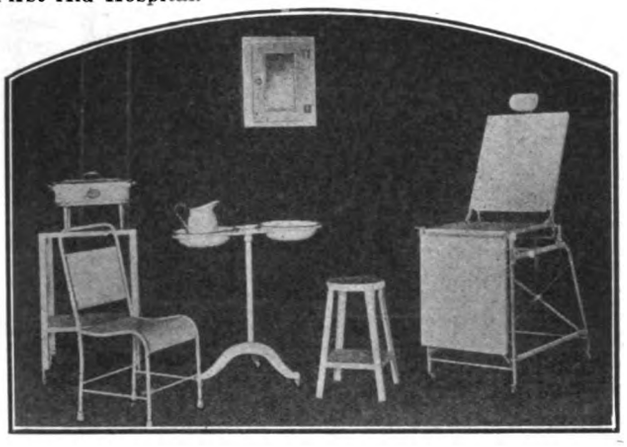
First Aid Supplies and Equipment

M-S-A First Aid Equipment is produced in our factory devoted solely to that purpose. It is an assurance of the highest quality of materials, absolutely sterile, designed particularly for mine use.

M-S-A First Aid Contest Outfit

M-S-A Emergency Hospital Group

The M-S-A line includes the equipment needed by the First Aid Hospital.

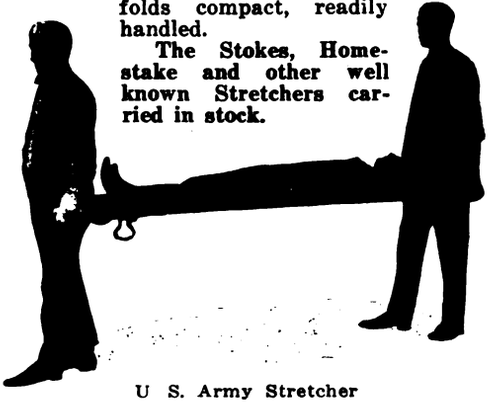


M-S-A Emergency Hospital Group

U. S. Army Stretcher

The standard stretcher of the Country. Light, folds compact, readily handled.

The Stokes, Homestake and other well known Stretchers carried in stock.



U S. Army Stretcher

M-S-A Special Strecher Outfit

Equipped complete with every essential to give first aid in any emergency—Stretcher, Double Wool Blanket, Rubber Blanket, Splints, 4 First Aid Packets, 4 Triangular Bandages and 4 Muslin Rolls.

M-S-A Special Stretcher Outfit

Packed complete in substantial galvanized canister, dust and moisture proof. Conforms to Compensation Insurance requirements as an inside dressing station.

M-S-A First Aid Contest Outfit

A strong box, under lock and key, equipped with Army Stretcher and all the materials suggested by the U. S. Bureau of Mines. Your team will need this outfit at the next contest.

Also practice outfits for team training; Meet Prizes and Efficiency Prizes. Prices on application. Immediate shipment.

M-S-A First Aid Cabinet—No. 8

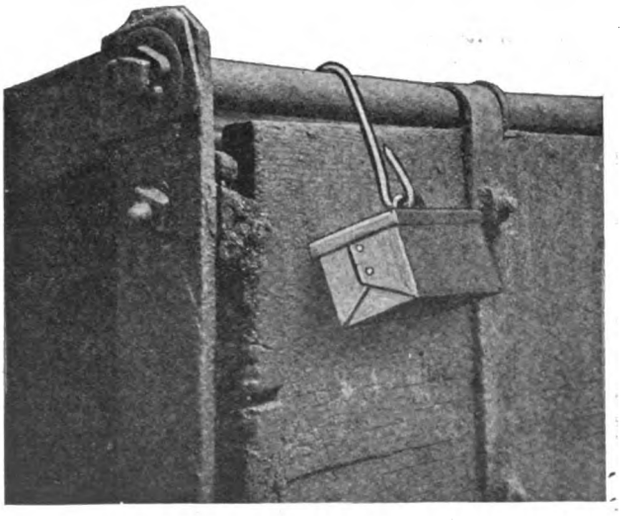
Hangs on the wall ready for instant use. Opened, the lid serves as a table. Size 17x10x3½". Weighs complete 8½ lbs. Equipped with every essential; fulfills Compensation Insurance requirements. Needed in every mine.

The M-S-A is the most complete line of Pocket Packets, Compresses, Dressings, and other First Aid essentials.

M-S-A First Aid Cabinet No. 8

Mining Machine Bit Box

Prevents loss of bits and boxes.
Keeps bits and boxes out of coal crushers.
Handle locks the lid in place.
Made of 12 Gauge steel, lap riveted, in two sizes; for 65 bits and 120 bits.



Mining Machine Bit Box

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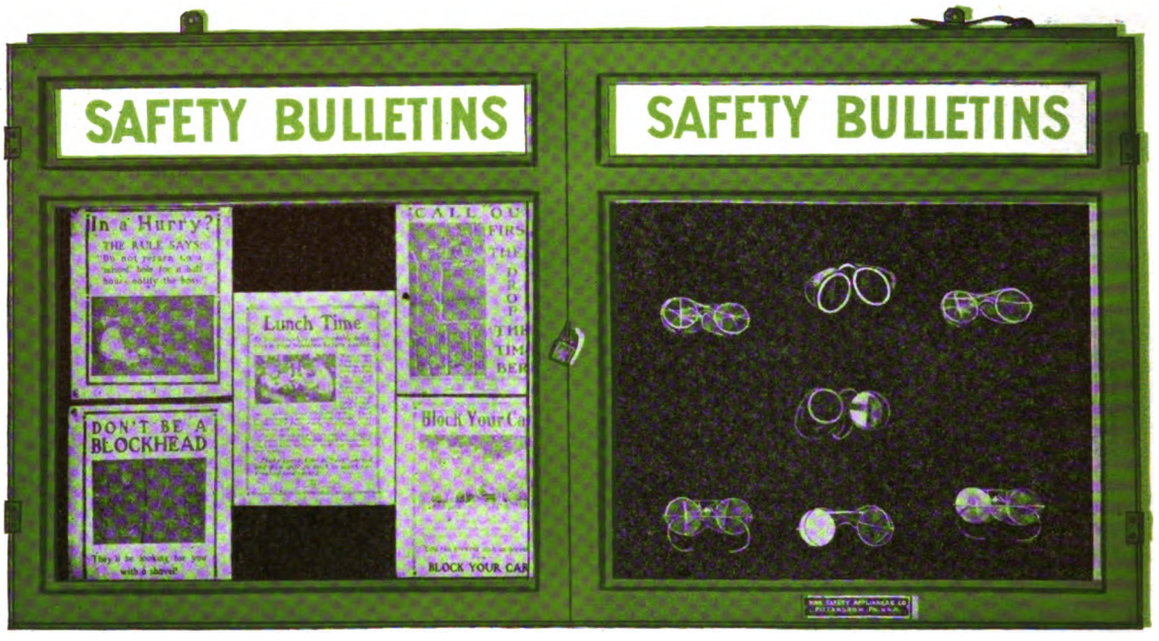
M-S-A Bulletin Boards

Attract and hold the eye. Built to withstand hard usage and the most severe weather conditions. Experience proves them a practical installation and a paying investment.



Bulletin Board No. 54
(No. 28 Is Exactly Half Size of No. 54)

Description—Size 56x30x4 inches. Two doors swinging freely on substantial hinges, with glass solidly embedded. Heavy metal straps at top for hanging. Built of 22-gauge sheet steel finished in durable green enamel. Removable wall board panel for posting bulletins.

Illumination—Two lamps on each side at top, brilliantly illuminate the green glass "Safety Bulletin" sign. Light reflects downward and illuminates display. Wiring in full accordance with insurance standards, to suit line voltage.

Playground Equipment

The most belittered weed-grown lot, any unused portion of a factory site, may be changed in a few days into a veritable haven for the children.

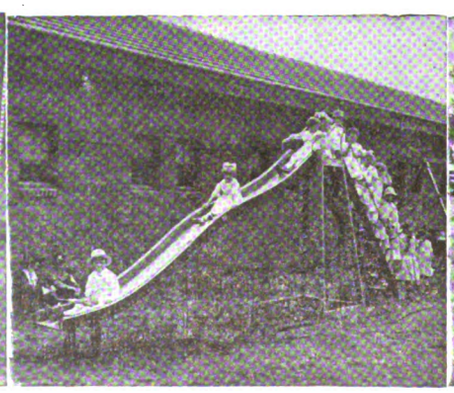
Everything for the Playground

Sufficient equipment is the basis of playground success. We can furnish Swings and Slides, Trapeze and Flying Rings, Basket Balls, Giant Strides and miniature Slides for the little toddlers.

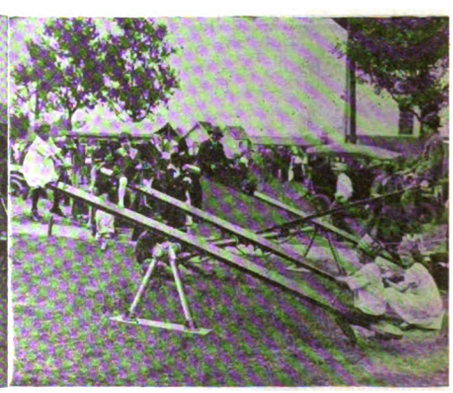
M-S-A Equipment offers you every facility for providing just what produces the greatest enjoyment—just what will be adapted to your grounds to make it a permanent success.

Let us furnish a plan and estimates suitable to your requirements.

Box Swing



School Slide



See-Saw Outfit

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SIGNS

Porcelain enameled on 18 gauge steel, or Lithographed on 26 or 30 gauge steel.

Each sign standard for the purpose intended; Standard Coloring, Standard Design.

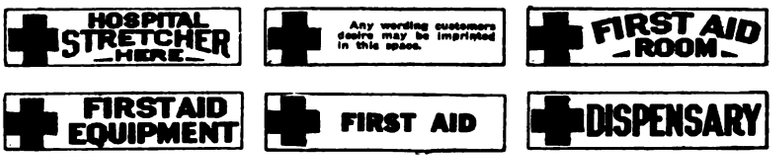
Approved by Accident and Liability Insurance Companies, State Inspectors and Workmen's Compensation Boards.

Red Cross Signs are standard in 3-color size 3½" x 14" enameled or lithographed.

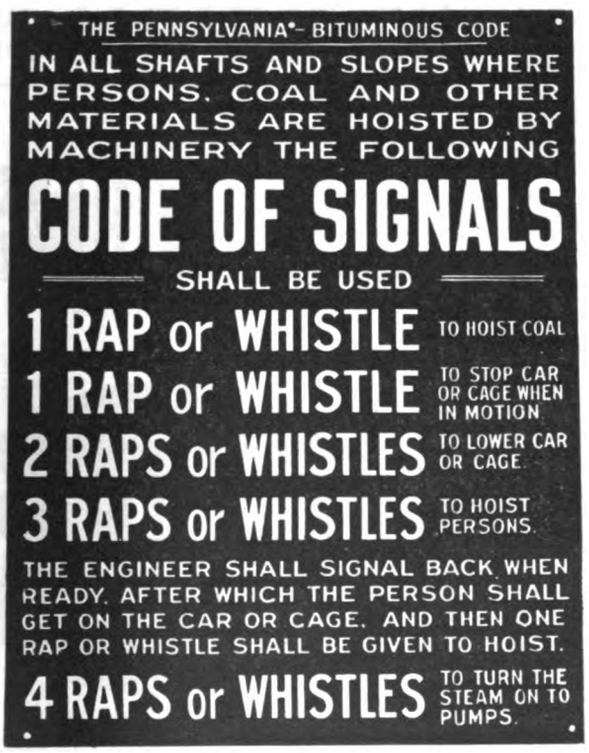
Panel Signs standard with white letters on deep blue blackground; 40 stock wordings; size 4" x 24" enameled only.

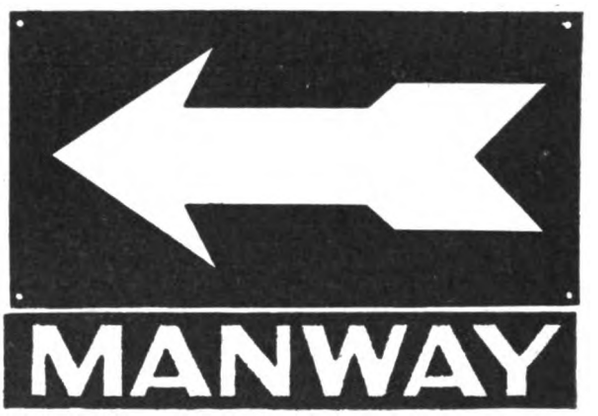
Hoisting Codes or General Rules to Employes made in any suitable size are standard in porcelain enamel, white letters on blue background.

Send for complete catalog and price list of stock Danger, Caution, Notice, Direction and Safety First signs. In asking for quotations on special signs, give size, colors, wording and submit special sketch if possible.



No. 106A. 10 in. x 14 in., 30 gauge—60 stock wordings
No. 206A. 14 in. x 20 in., 30 gauge—40 stock wordings





No. 011M. 26-gauge Steel.

No. 001. 10 in. x 24 in., 26-gauge Steel.

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SAFETY FIRST SUPPLY COMPANY

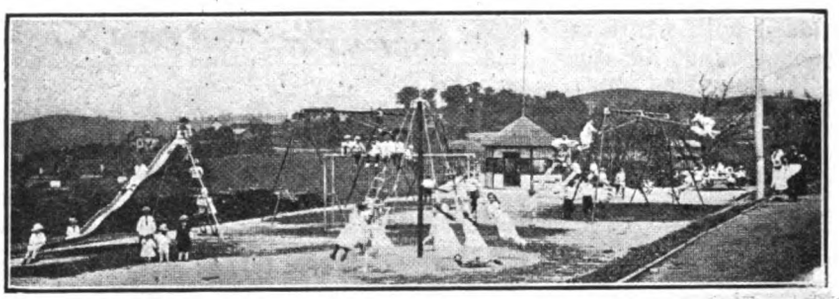
107 Third Ave., PITTSBURGH, PA.

Branches

Huntington, W. Va. Cincinnati, Ohio Philadelphia, Pa.

Everything for Safety, First Aid and Welfare

DIAMOND ALL-STEEL PLAYGROUND APPARATUS



Will keep the children healthy and happy and provide a place where they can put to good use their youthful enthusiasm which would otherwise find expression in mischief or in dangerous places where their presence would be a source of hindrance and annoyance to the operation of the mine.

Then, too, grown-ups will use the Playground as a social center and will derive as much pleasure from the use of the apparatus as the children.

DIAMOND All-Steel Playground Equipment is the most serviceable and durable that it is possible to install. The Fittings used in its construction are ALL STEEL and the apparatus is perfectly rigid and safe.

Plans and Prices Gladly Submitted
Send for Our Booklet "Proof of Service"

DIAMOND PORCELAIN ENAMEL SIGNS

No. 132. Size 18x10 Inches.

No. 154. Size 10x12 Inches.

No. 123. Size 14x6 Inches.

No. 324. Size 14x7 Inches.

No. 114. Size 8x4 Inches.

No. 290. Size 16x4 Inches.

No. 55—Size 14x4 Inches.

No. 316. Size 14x12½ Inches.

No. 293. Size 14x10 Inches

DIAMOND PORCELAIN ENAMEL SIGNS are manufactured of five coats of PORCELAIN ENAMEL, fused at 2000 degrees heat on 18-GAUGE IRON. We guarantee these signs to stay bright and clean, to be unaffected by weather conditions or acid fumes, and to last indefinitely. Screw holes are each protected with patent collar, eliminating danger of injury to sign when posting.

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Look over the list below of some of the Safety, First Aid and Welfare Equipment which we carry in stock, ready for immediate shipment, and let us quote you on your requirements.

Porcelain Enamel Signs
Bulletin Boards
Goggles
Machinery Guards
Ladder Shoes
Respirators
Fire Extinguishers
Asbestos, Leather and Rubber Gloves
Mine Tail Lanterns
Drinking Fountains
Safety Cans
Stokes Splint Stretcher
Hospital Equipment
First Aid Pocket Packets
Emergency Outfits
Protective Clothing
Sanitary Clothes Hangers
Post Pullers
Flexco-Lok Lamp Guards
First Aid Cases
Gongs—Alarm and Signal
Playground Apparatus
Safety Truck Brake
Masks, Helmets and Safety Hats
Portalites

Diamond No. 2 First Aid Case

Diamond No. 2 First Aid Case

Cabinet is made of heavy, decorated metal and is provided with rings to hang cabinet against the wall and handles efficient for carrying.

Size: Length, 20 inches; width, 13 inches; depth, 3½ inches.

Weight: 12 pounds.

Diamond Illuminated Improved Bulletin Boards

Are built for hard service—weatherproof and dust-tight. Material throughout is galvanized steel. Each board is wired for lamps which shine through opal glass sign at top of board and afford perfect illumination of contents of board. Made in three sizes.

Diamond Bulletin Board No. 28

Diamond Point Ladder Shoe

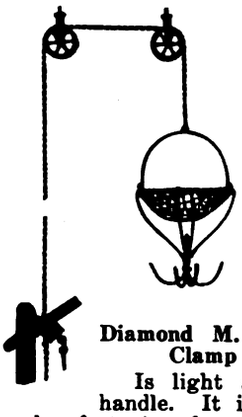
Diamond First Aid Finger Cot

An efficient Muslin Dressing, designed to hold the finger bandage in place; clean and sanitary.

Diamond Point Ladder Shoes

Manufactured of 1¼x3/16 inch wrought iron, heavily galvanized. Removable, renewable Tool Steel Points. Adaptable to any kind of ladder.

Diamond First Aid Finger Cot



The Diamond Sanitary Clothes Hanger

Is a safe way to take care of the miner's clothes while he is in the mine and is a safe, convenient way to care for his working clothes while off duty. Basket is made of one piece of heavy galvanized wire. Has no loose parts to get lost—is one simple, connected unit.

Diamond M. & M. Rail Clamp

Diamond M. & M. Rail Clamp

Is light and easy to handle. It is the surest and safest stop for use on Crane Runways and Surface Tracks.

Goggles

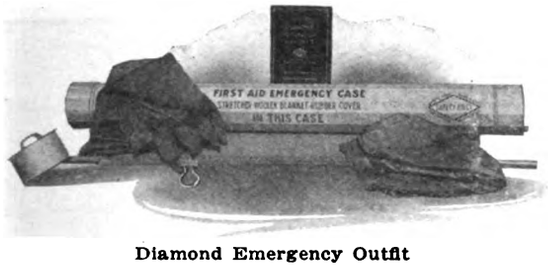
Used for chipping, grinding, stone cutting and general industrial purposes.

Will withstand severe blows and will not shatter when broken.

Diamond Adjustable Goggle With Head Bands.

Diamond Emergency Outfit

Consists of U. S. Army Stretcher, heavy wool blanket, heavy rubber blanket contained in galvanized iron Canister, together with Diamond No. 2 First Aid Case. Absolutely Dust and Moisture-proof, clean, sanitary and guaranteed to meet Insurance Requirements.



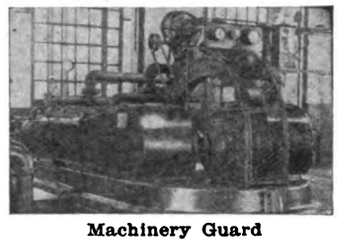
Diamond Emergency Outfit

Dustite Respirator

Made of white rubber, with aluminum ring for holding the gauze filter. All parts are separately renewable. Tested and approved by The Underwriters' Laboratories.

Machinery Guards

We are prepared to manufacture guards for all machinery. Using DIAMOND EXPANDED METAL, hand riveted to angle iron frames, from your own blue prints or measurements made by our Engineers.

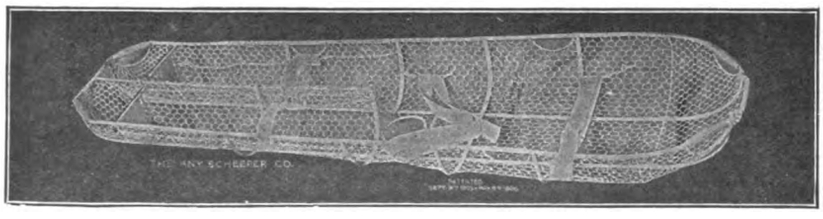


Machinery Guard

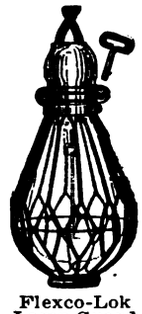
Trip Alarm

Stokes Splint Stretcher

A heavy steel wire basket, reinforced and braced with handles at the sides and corners. It may be handled by one person when necessary, the bottom braces serving as runners. Adjustable foot plates and bandages serve to secure the occupant so that he may be carried up steep inclines or shafts in any convenient manner without danger of further injury.



Stokes Splint Stretcher



Flexco-Lok Lamp Guard

Our Complete Catalog—Invaluable to Safety Engineers or Anyone Interested in Safety, First Aid and Welfare—Mailed on Request

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HYGIENIC FIBRE COMPANY

200 Broadway, NEW YORK CITY

I. D. P.

Trade Mark

Individual Dressing Packets

Surgical Gauze **Absorbent Cotton** **Prepared Bandages**

Individual Dressing Packets for Emergency Use in First Aid

Individual Dressing Packets furnish prompt, proper and adequate First Aid treatment in all emergencies, and prevent useless expense due to the waste of materials frequently encountered in the use of usual methods of furnishing first aid materials. These Packets are the most economical form of First Aid treatment for the protection of workers wherever the services of physician or nurse are not immediately available.

Each Individual Dressing Packet contains one or more First Aid Dressings or Treatments for a definite injury; specially prepared, ready for instant use, complete in itself, and sufficient for the purpose. Compresses and bandages are ready prepared. There can be no waste in their use. Full directions are given on each Packet by words and pictures; they can be applied instantly by anyone. This is the modern, most efficient, least wasteful and least expensive way to supply the best possible First Aid materials for male or female help in office, shop, factory or mine; for single or group workers; in minor and major injuries.

The following list covers the Individual Dressing Packets prepared for standard use:

No. 1 Packet—one 4-inch compress
No. 2 Packet—two 3-inch compresses
No. 2A Packet—one 3-inch compress
No. 3 Packet—four 1¾-inch compresses
No. 3A Packet—one 1½-inch compress
No. 4 Packet—ten Iodine Ampoules
No. 4A Packet—one Iodine Ampoule
No. 5 Packet—ten Ammonia Inhalants
No. 5A Packet—one Ammonia Inhalant
No. 6 Packet—six tubes Borated Petrolatum
No. 6A Packet—one tube Borated Petrolatum
No. 7 Packet—one triangular Bandage
No. 8 Packet—two Tourniquets
No. 8A Packet—one Tourniquet; one pair Forceps
No. 9 Packet—one Wire Splint
No. 10 Packet—one Bandage
No. 11 Packet—one Compress
No. 12 Packet—Eye Dressings—one Eye Cup; Boric Acid Tablets; three Vials Castor Oil
No. 13 Packet—Internal Remedies
No. 14 Packet—Ten Ampoules Chloramine—T
No. 14A Packet—One Ampoule Chloramine—T
No. 15 Packet—1-inch x 6-yard Bandage
No. 16 Packet—2½-inch x 6-yard Bandage
No. 17 Packet—ten Drinking Cups
No. 18 Packet—Four Ampoules (2cc) Aromatic Spirits of Ammonia

In addition to the above, Individual Dressing Packets will be designed to contain other than standard contents; any desired medication or any required form of dressing not included above can be prepared to meet the needs of any particular risks, or the recommendations of any surgeon, physician or nurse.

Individual Dressing Packets with either standard or specially prepared contents, may be put up in kits to be carried by lone or group workmen; and in cabinets for use on motor trucks, locomotives, in emergency hospitals, etc., etc.

We invite inquiries regarding specially designed kits and cabinets and offer the services of our organization in preparing I.D.P. to meet your particular requirements.

Individual Dressing Packets in Standardized Kits

Such as shown here prevent waste and provide prompt adequate first aid treatment right on the spot. Workmen use I. D. P. because they are handy and convenient. The Kit at the left is for individual workmen, while the one at the right is for use where groups and gangs are working together.

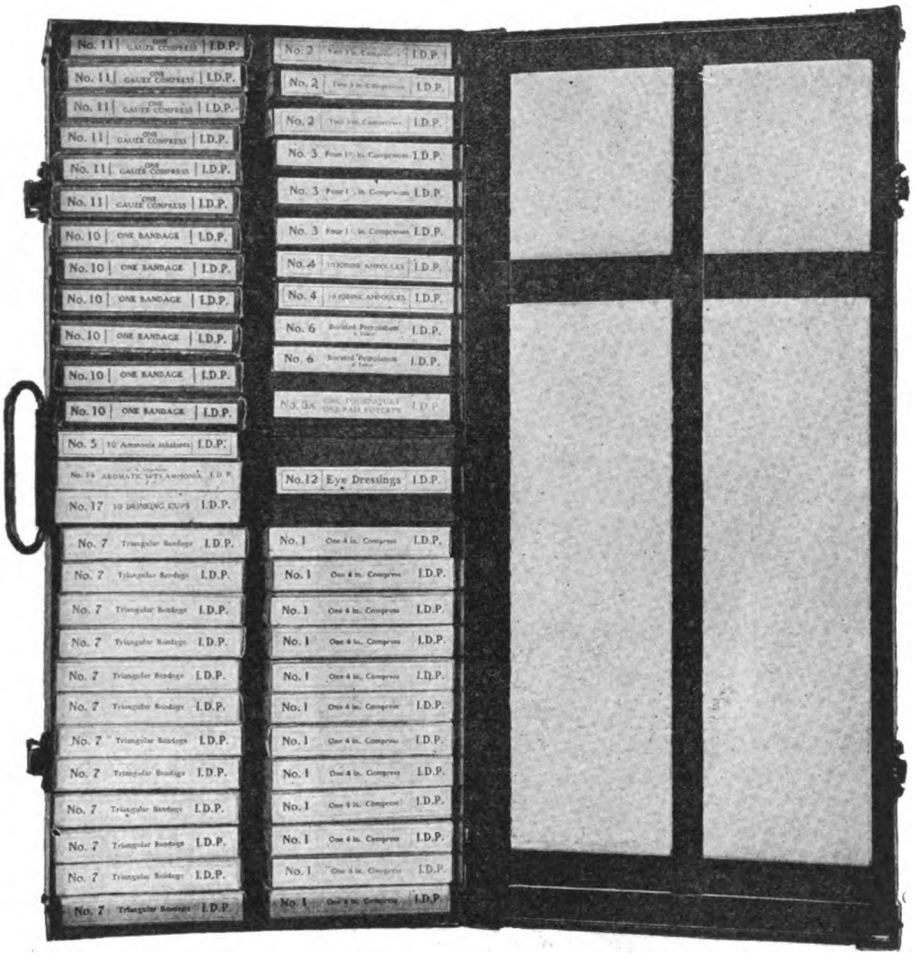
Digitized by Google

Individual Dressing Packets

Absorbent Cotton
Surgical Gauze **Prepared Bandages**

Individual Dressing Packets in Specially Designed Cabinet for Mines

The cabinet shown at the right has been specially designed to meet the hazards of the average mine. The Packets are enclosed in a metal, rust-proof cabinet; each Packet distinctly labeled and all arranged in logical order.



The cabinet is well adapted for use in underground workings and offers first aid treatment of the most efficient character, in such easily applied form that the most inexperienced person can quickly and easily render first aid. The Individual Dressing Packet method permits economies not possible with ordinary first aid cabinets because only the dressings actually needed are opened and used.

Individual Dressing Packets Will Be Prepared to Meet the Requirements of Your Surgeon

Absorbent Cotton
Surgical Gauze
Prepared Bandages

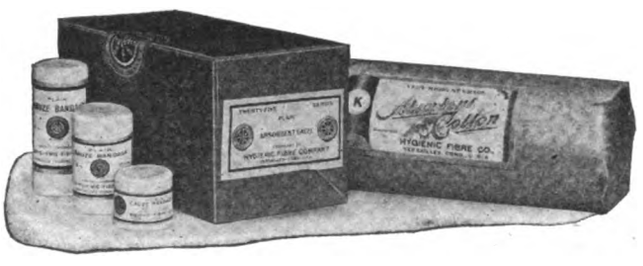
We operate a large laboratory for the preparation of Absorbent Surgical Dressings and can furnish these in all standard forms:

Absorbent Cotton in 1 lb. rolls, and in 1 lb. 8 oz., 4 oz., 2 oz. and 1 oz. cartons.

Surgical Gauze in 100 yd. Oval Rolls or Flat Folds, 36 in. wide; and in 5 yd. and 25 yd. cartons.

Prepared Bandages in 10 yd. lengths and in 1 in. to 4 in. widths.

Hygienic-Made Cotton, Gauze and Bandages are well known and used extensively in hospitals everywhere. They are prepared in a sanitary sunlit laboratory, are always of first quality and sold on a "Best by Test" basis. We solicit your inquiries for Cotton, Gauze and Bandages and will be glad to quote current prices.



HYGIENIC FIBRE COMPANY
First Aid Department
200 Broadway **New York City**

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DURAND STEEL LOCKER COMPANY

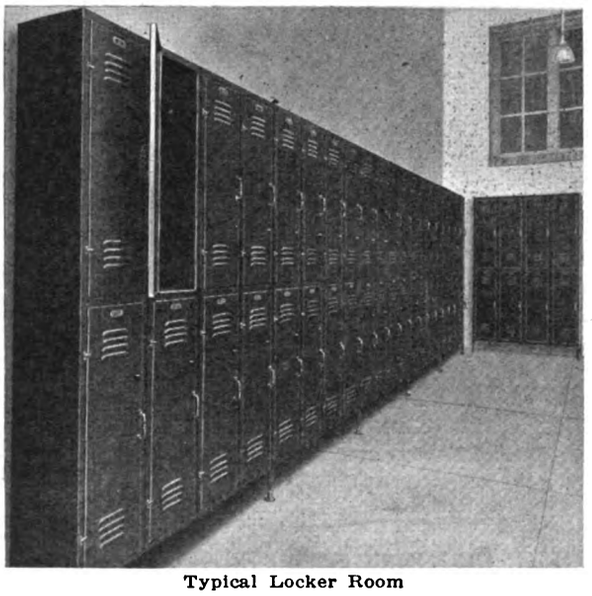
1845 Park Bldg. NEW YORK | 1545 Fort Dearborn Bank Bldg. CHICAGO | 1545 General Motors Bldg. DETROIT

Steel Racks and Lockers

Durand Steel Lockers

Durand Steel Lockers, made up in several types, single and double tier, provide for sanitary, safe storage of clothing and personal effects. They are characterized by strength, simplicity of design, and efficiency of operation.

Locker doors are of No. 16 U. S. S. gauge fully pickled and patent leveled steel; body of No. 22 U. S. S. gauge one pass cold rolled sheet steel. Doors are hung in a rigid frame composed of 1x1x⅛ inch angles, oxyacetylene welded. Doors may be furnished perforated or with pressed (louvre) ventilation slots.



Typical Locker Room

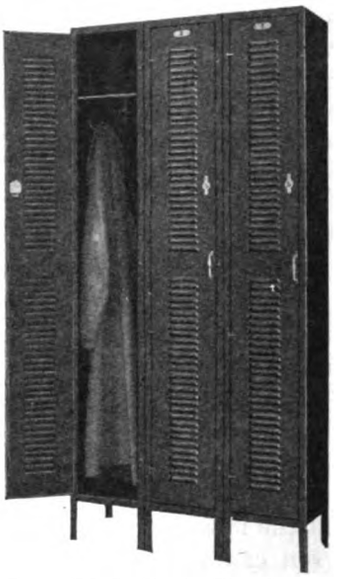
The Durand Hinge consists of only two parts, a stationary staple of 3/16 inch steel riveted through the steel angle frame, and a rotating hinge, blanked solid out of 9/64 inch cold rolled steel, pierced for the staple to pass through it. This is the strongest and yet the least conspicuous locker hinge made.

The Durand Multiple Locking Device locks the door at three points, and is operated by a simple and efficient handle. Yale locks, with flat or grooved keys, or padlocks furnished.

Finish is olive green; steel is thoroughly cleaned and two coats of enamel are applied by dipping and are baked separately.

All lockers are shipped knocked down and may be erected by ordinary labor, or on large installations we can send our mechanics to the building.

Double tier lockers are regularly furnished 12", 15", 18" wide by 12", 15", 18" deep by 36" or 48" high. Single tier lockers are regularly furnished 12", 15", 18" wide by 12", 15", 18", 24" deep by 60" or 72" high; also 24" wide in 72" high locker.



Type F.L.S. Single Tier Locker

Where a locker is desired with special facilities, we can furnish:

Wardrobe locker of extra width, with hat shelf and coat rod.

Hat and coat combination with one compartment for coats and six smaller compartments for hats.

Divided locker, regular standard with extra partition, for separate hanging of street and shop clothes.

Steel Storage Lockers

The Durand Steel Storage Locker is invaluable for the safekeeping of files, records, etc., such as are too bulky to store in the ordinary safe; also for storing valuable plans, patterns, dies, gauges, or delicate instruments.

Steel Storage Locker

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Durand Steel Racks

Durand Standard Steel Racks are easily adjustable by hand to form compartments of practically any size or proportions, with the aid of dividers, bin fronts, or Durand Steel Boxes for minute articles. Counters, backs, and label holders also can be furnished.

Durand Skeleton Racks form open boltless structures for the storage of packaged stock.

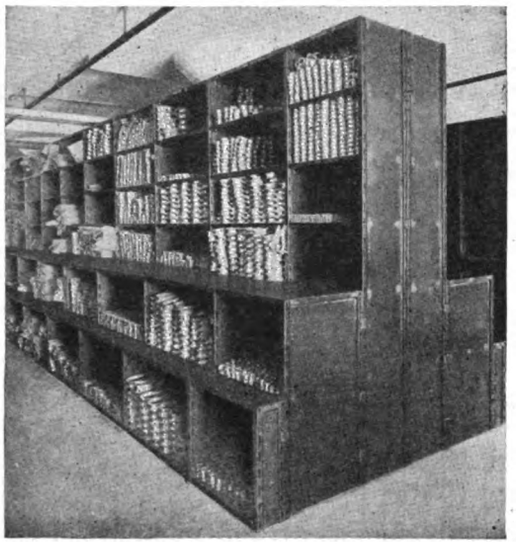
Both Standard and Skeleton types have sustained loads of 1000 lbs. per sq. ft. without exceeding their bending strength, and will carry an unevenly distributed load of 200 to 400 lbs. per sq. ft., depending on their area.

Steel Racks With Small Compartments

Uprights are composed of 1¼" square tubes of No. 16 U. S. S. gauge steel, punched on 3" centers for shelf adjustment.

Lengthwise bearers are ¼"x1" rolled steel bars grooved at the ends to be a wedging fit in slots in uprights. Crosswise bearers are 1"x⅝"x⅛" angles with tapered notches that wedge on the lengthwise bearers and lugs that engage the slots in the upright tubes.

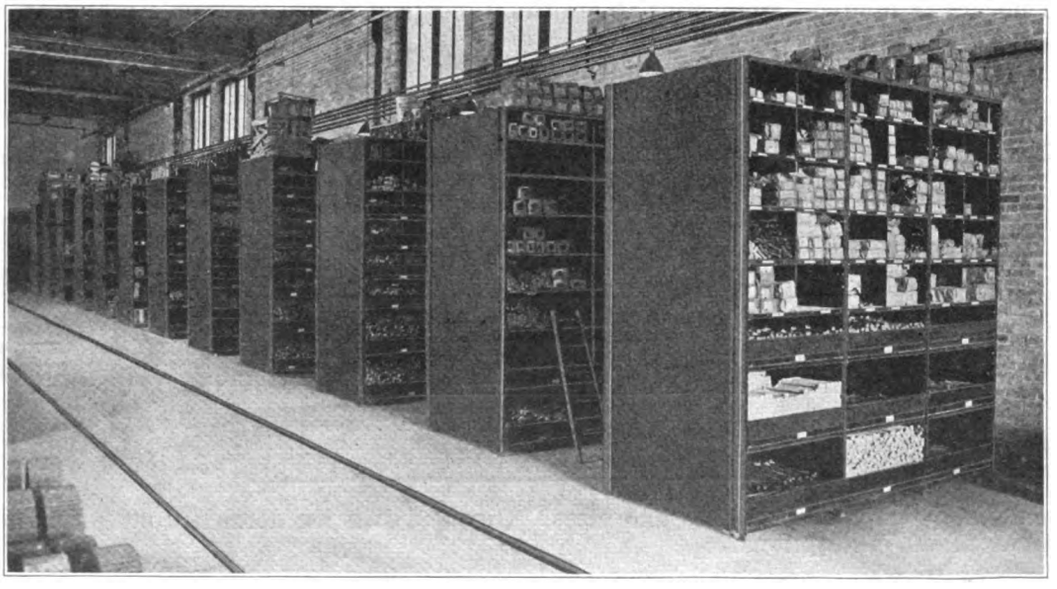
Shelves are of No. 16 U. S. S. gauge steel flanged downward 1" and back 5/16" at the front and back, and downward 1" at the sides.



Steel Racks With Large Compartments

Practically every storage problem can be met with Durand Steel Racks and Shelving. They save floor space and time of employees; they are clean, sanitary, and fire-proof; they are easily rearranged or removed; and they are a permanent asset of equipment.

Send for Catalogue O, or consult with our engineers regarding your special storage problems. The Durand Steel Locker Company is always ready to prepare layouts, plans and specifications and to submit estimates for steel locker or rack and shelving equipment.



Steel Racks Solve All Storage Problems

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JAMES H. CHANNON MFG. CO.

225-227 West Erie Street, CHICAGO, U. S. A.

Equipment for Mines and Quarries

For Wash and Change Houses—For Mine, Mill and Factory

Mine operators everywhere have proved to themselves that it pays to give attention to hygienic working conditions, on which depend health, comfort, contentment and good feeling, regularity of attendance and maximum production.

Booklet "High and Dry" Sent Free on Request

UNION SANITARY CLOTHES HANGERS

Consequently, the James H. Channon Original "Union" Sanitary Clothes Hanger is rapidly displacing the stuffy, ill-ventilated, germ-breeding steel locker.

Its practical advantages are self-evident: The stout, rust-proof basket, deep and capacious, holds the workman's lunch and valuables in safety. The ample, rust-proof four-prong hook spreads his damp clothing to the fresh, warm, drying air. The sturdy sherardized chain (tested to 1,000 pounds) hoists all to the ceiling, where the air-currents are warmest. The strong padlock secures the outfit from molestation.

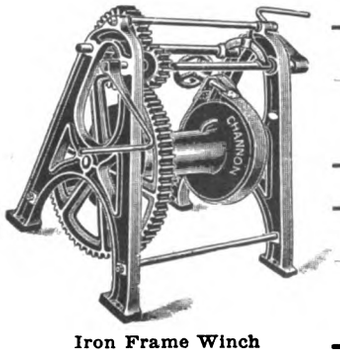
The illustration shows a standard Hanger unit, which includes thirty feet of chain, the length that meets average requirements (for 15-foot ceiling).

The saving, as against steel-locker installation, is about three-quarters in first cost; and about two-thirds in floor-space required. The Hanger effects a further large saving in repair-cost; for when a workman forgets his key and pries the steel locker open with a pick, the repair-cost is greater than the cost of an entire "Union" Hanger unit. Fire-risk from spontaneous combustion is eliminated, and from pipes left in clothing greatly diminished.

Whether or not your State or Province has legislation making Hanger or Locker provision for workmen compulsory, self-interest will suggest that you investigate this, by far the best and cheapest high-grade Wash-Room Equipment.

Correspondence is invited—from Mine Operators, Industrial Engineers, and Architects. Model Wash-Room Layout will be sent on requent.

HOISTING EQUIPMENT OF ALL DESCRIPTIONS



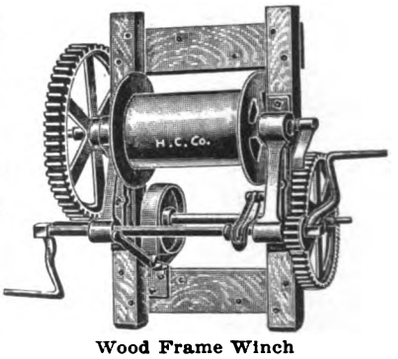
Iron Frame Winch

No. 30—CAST-IRON FRAME

Size Order No.	Diameter and Length of Drum	Diameter of Gears and Pinions	Pull of 2 Men on Single Line, Lbs.	Speed of Rope Ft. per Min. on Drum
300	4½ x 16	16- 6 and 4	3,000	1¾
301	4½ x 20	20- 6 and 4	4,000	2½
302	5½ x 20	24- 9 and 5	5,000	3½
303	8½ x 16	24- 9 and 5	5,000	4½
304	8½ x 20	30-15 and 5	6,000	5½

No. 25—WOOD FRAME

Size Order No.	Diameter and Length of Drum	Diameter of Gears and Pinions	Pull of 2 Men on Single Line, Lbs.	Speed of Rope Ft. per Min. on Drum
250	5 x 16	20-16 and 4	1,800	2½
251	5 x 24	20-16 and 4	1,800	2½
252	6 x 21	20-16 and 4½	1,800	4
253	6 x 30	24-16 and 4½	2,500	1½
254	**9 x 16**	**24-16 and 4½**	**2,500**	**2¼**



Wood Frame Winch

We can furnish many other styles and sizes. Guy and stiff leg derrick irons for power and hand power derricks of all descriptions.

WRITE FOR OUR GENERAL CATALOGUE, NUMBER 60

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HOWE FIRE APPARATUS CO.

ANDERSON, INDIANA

NEW YORK—30 E. 42nd St. UPTON, MASS.—15 Grove St.

Fire Apparatus and Portable Pumps

The Howe-Ford

The Howe-Ford Fire Engine is especially well adapted for mining towns with their hilly unpaved streets, blocks of one- and two-story houses, and volunteer firemen.

The double power transmission gives this machine four speeds forward and two reverse; doubles the power on all the regular Ford speeds; gives power to go over bad roads and up hill with a full load where the ordinary Ford fire-truck would be helplessly stalled.

Often mining towns are not permanent. For them the Howe-Ford has ample power, capacity and speed at a minimum cost.

Our piston pump will throw one, two and three streams higher than a four-story building and will boost a weak, inefficient stream to 125 pounds pressure, which is considered abundant for towns with buildings not over four or five stories.

Our booster pump chemical is considered the most reliable and satisfactory chemical made for volunteer fire companies. It will not freeze in the coldest weather and as it contains no sulphuric acid it is perfectly safe for volunteer firemen to use. The supply is practically inexhaustible. It carries a higher and steadier nozzle pressure than does the acid chemical. The agitation of the chemical fluid is automatic and constant while the stream is in operation. The machine is built to carry, besides the pump: chemical equipment; 750 to 1,000 feet of fire hose; a complete outfit of ladders and firefighting tools; and six to eight firemen.

It is an indisputable fact that the universal Ford is the most easily operated machine. Supplies and repairs are more readily and economically obtained than for any other automobile. Therefore it is the best suited for the volunteer firemen in the smaller cities and towns.

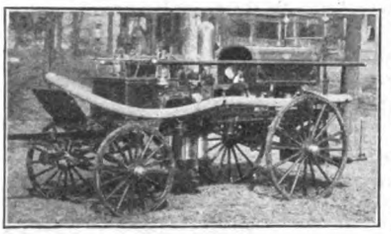
The Howe-Reo

The Howe-Reo is a combination pumper- chemical engine- and hose-equipment designed for the towns that want extra power, capacity and speed at a moderate price.

Howe-Reo Pumper

Gasoline and Steam Engine, Horse- and Hand-Drawn Pumpers at Bargain Prices

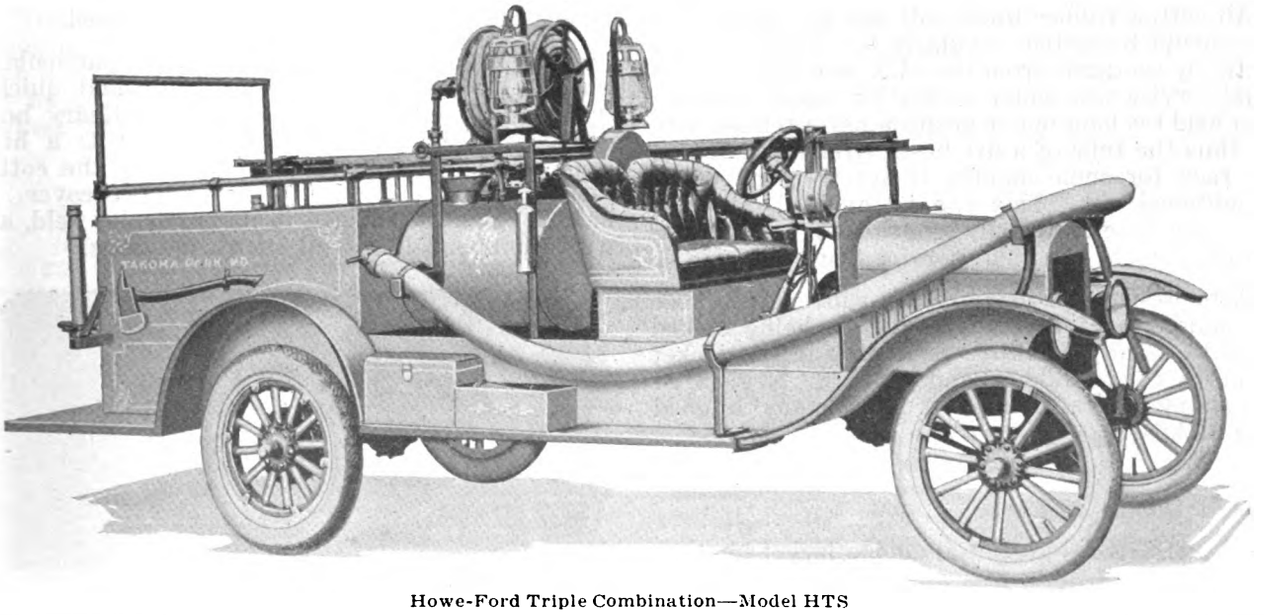
We always have used pumpers which we have taken as part payment on new equipment and have rebuilt to be sold at bargain prices. They have a capacity of ten barrels per minute and upwards; will carry a pressure of 100 to 150 pounds and throw powerful streams 125 to 150 feet. They are ideal for pumping out flooded mines, sumps, etc.



Horse-Drawn Pumper

Howe Double-Power Transmissions for Commercial Trucks

The ordinary Ford must be loaded light enough for the steepest grade of the worst piece of road to be traveled. With the Howe-transmission however, the power is doubled and the efficiency of the truck increased accordingly and on a Ford commercial car will pay its cost in a few months. We furnish the transmission with shortened radius rods, drive shaft and housing, so any garage can install it in a short time.



Howe-Ford Triple Combination—Model HTS

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THE B. F. GOODRICH RUBBER CO.

AKRON, OHIO

Branches		Branches
Atlanta, Ga.		Detroit, Mich.
Baltimore, Md.		Kansas City, Mo.
Boston, Mass.		Los Angeles, Cal.
Buffalo, N. Y.		New York, N. Y.
Chicago, Ill.		Philadelphia, Pa.
Dallas, Texas		San Francisco, Cal.
Denver, Colo.		Seattle, Wash.

THE INTERNATIONAL B. F. GOODRICH CORP.
London Capetown Singapore

Fire Protection and Water Hose

Mechanical Rubber Goods of Every Description

For Transmission Belts, see pages 206 and 207; for Conveyor and Elevator Belts, see pages 662 to 666; for Air Drill Hose, see pages 303; for Steam Hose and Packing, see pages 190 and 191.

Hose For Fire Protection

Hose for fire protection purposes should be chosen with these ideas in mind:

1. Is it likely to be used fairly often, or is the danger of fire slight?

2. Is it to be used under high pressure, or under ordinary hydrant pressure?

3. Is it exposed to moisture or to fumes of an injurious nature to the cotton jacket?

The type of hose you will choose will be largely dictated by these considerations, and we have tried to indicate in describing our various brands, what that choice should be.

All cotton rubber lined mill and fire protection hose should be tested regularly, at least once a month, by taking it from the rack, and giving it an actual service test under normal pressure. Rubber, when held too long in one position has a tendency to set; thus the tube of a fire hose, after being folded in a rack for some months is apt to crack when straightened out. This can be avoided, and the life of the hose materially lengthened, by the simple expedient of a regular service test.

After testing, or using cotton rubber lined hose it should be carefully dried out before being racked up again, as any moisture remaining in the jacket is apt to cause mildew and rotting. Neglect of this simple precaution has ruined many a good piece of hose.

Summit Double Jacket

SUMMIT is a substantial double jacket hose for use where high pressures are the rule. The two closely woven, high grade jackets provide ample strength to resist high pressures, and the tube is of a quality that will resist to the utmost the deteriorating influences of time. It should be your choice for outside use in connection with fire hydrants.

Mainstay Single Jacket

This is our highest grade single jacket hose—built to withstand heavy wear and abuse without showing signs of distress. It has an even higher quality tube than SUMMIT, and its life, even when racked up for months at a time without being used, is remarkable.

Commander Single Jacket Rubber Covered

COMMANDER has been designed particularly for use where excessive moisture would quickly cause mildewing of the jackets of ordinary hose, or where acid fumes are present. It is a high grade single jacket type of hose with the cotton jacket protected by an outside rubber cover. It has proven most efficient in its particular field, and we recommend it for all such conditions.

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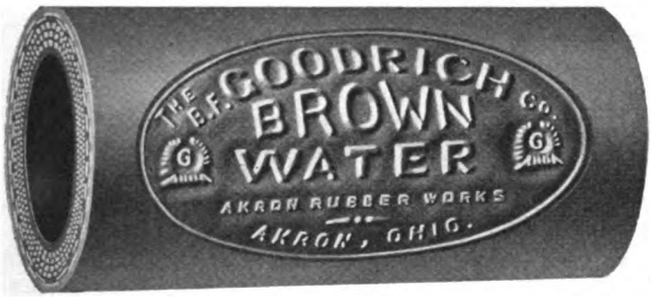
Fire Protection and Water Hose

Many people make the mistake of supposing that anything that will not leak will make a satisfactory water hose. This is far from the truth, for the problems encountered in water hose service are just as numerous and difficult of solution as those met with in any other line of service.

Practically all water hose is subject to more or less external wear and abuse and this factor should be taken into consideration in determining the quality to be purchased.

Goodrich Brown Water Hose

This is as high a grade of water hose as it is possible to produce and one which has made exceptional service records in many and varied industries. It is of the combination type, consisting of several plies of stout fabric wrapped around the tube with a continuous seamless ply braided over this carcass and the whole protected by a tough brown cover. It will stand up and deliver service long after the ordinary water hose has been consigned to the scrap heap.



Triton Brand

Triton Hose is practically the equivalent in construction of Goodrich Brown Water Hose except that it is of the standard wrapped type and does not have the exceptional brown cover. It is the highest grade standard type water hose produced.

Cascade Brand

Cascade Brand is a splendid quality wrapped hose for service where operating conditions are not so severe as to demand Goodrich Brown Water or Triton. It will give service far beyond that of most competitive hose.

Akron Brand

For those who prefer the braided type with the advantage of always being able to secure continuous lengths up to 500 feet, Akron will prove entirely satisfactory. It has the quality of both tube and cover necessary to meet severe operating conditions and a fabric strength sufficient to withstand high pressures. The fact that the fabric body is made of continuous seamless braids, eliminates any possibility of unwrapping due to the wearing off of the cover and loosening of the adhesion between the plies or braids.

HOSE COUPLINGS

Next to the choice of the proper hose for the service the most important thing is to make sure that the couplings are properly attached. A majority of hose troubles can be laid to faulty attachments of couplings, and it is with the idea of correcting these abuses that we are prompted to give the following hints:

(1) Remove all burrs or sharp points from stem of couplings or nipple. Round off end of stem so as not to cut tube.

(2) Coat the stem which is to be inserted into the hose, also the inside of the hose at the ends, with rubber cement, shellac, or soap and insert **without delay.**

(3) Fasten coupling or nipple in a vise, apply the rubber cement, shellac or soap, and then **draw the hose over the coupling.**

(4) If the stem of the coupling is too large to enter the hose do not cut away any portion of the tube to make the hole larger. Instead, it would be preferable and safer to either purchase couplings with right size stem or turn the stems down on a lathe.

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SECTION XXIII

General Machinery, Shop and Repair

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Allan Mfg. & Welding Corp.
American Brass Co.
Bradley, C. C. & Son, Inc.
Chicago Pneumatic Tool Co.
Hauck Manufacturing Co.
Imperial Brass Mfg. Co., The
International Nickel Co., The
Linde Air Products Co., The
Morse Bros. Machinery & Supply Co.
Oxweld Acetylene Co.
Prest-O-Lite Co., Inc., The
Salt Lake Hardware Co., The

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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Shop Wrinkles

RACK FOR HEAVY MATERIALS

A good rack for holding heavy materials, such as pipe, bars, and angles, and even lumber, may be made as follows: Bore holes in as many posts as desired at an angle that will be found to be convenient; insert short pieces of pipe of suitable length in the holes thus made; and fasten the vertical timbers both at the top and bottom. This will give a good serviceable rack. By boring holes from opposite sides and having "shelves" on both sides, it is evident that the rack will be better balanced than where one side only is used.

—By W. F. Schaphorst. Written for Eng. & Mng. Journal.

BOLT AND NUT TRAYS

In a mill that I recently visited the master mechanic had taken a lot of old elevator buckets and nailed them against the wall to hold the various sizes of bolts, nuts and washers for which there was constant use. A small hole had been bored in the bottom of each bucket, so that if water accidentally got in it would run out. Small-size buckets were used for the small-size hardware and big buckets for the large. The wedge shape of the buckets makes it possible to put them closer together and to get into them more conveniently than any other form of tray that I have seen.

—By Donald M. Liddell. Written for Eng. & Mng Journal.

A HANDY GEAR REDUCTION

When a slow revolving motion is needed, it is at times difficult to find anything suitable. A handy gear reduction can be made out of a tool grinder. A pulley disk of any size can be clamped in place of the emery wheel, and another disk, a pulley, or agitator arms can be attached to the shaft in place of the crank. By using different sizes of pulleys or disks made of wood or metal, nearly any speed ratio can be obtained. The gear reduction is usually 30 to 1.

—By Charles Labbe. Written for Eng. & Mng. Journal.

CEMENTS

For Holes in Castings

Sulphur in powder, 1 part; sal ammoniac, 2 parts; powdered iron turnings, 80 parts. Make into a thick paste. Make only as required for use.

* * * *

For Iron Ware

Sulphur, 2 parts; fine black lead, 1 part. Heat sulphur in an iron pan until it melts, then add the lead; stir well and remove. When cool break into pieces as required. Place upon opening of the ware to be mended and solder with an iron.

* * * *

For Rust Joint

(Quick Setting.) Sal ammoniac in powder, 1 pound; flour of sulphur, 2 pounds; iron borings, 80 pounds. Made to a paste with water.

(Slow Setting.) Sal ammoniac, 2 pounds; sulphur, 1 pound; iron borings, 200 pounds.

The latter cement is best if joint is not required for immediate use.

* * * *

For Uniting Leather and Metal

Wash metal with hot gelatine; steep leather in an infusion of nutgalls, hot, and bring the two together.

* * * *

For Uniting Wood to Iron

Finely powdered oxide of lead (litharge) and concentrated glycerine. This composition is insoluble in most acids, is unaffected by action of moderate heat, sets rapidly, and acquires an extraordinary hardness.

* * * *

For Uniting Stone to Iron

Take 10 parts of fine iron filings, 30 parts of plaster of paris, and one-half part of sal ammoniac; mix with weak vinegar to a fluid paste and apply at once.

* * * *

For Fastening Brass to Glass

Knead resin soap with one-half its weight of plaster of paris.

* * * *

Fastening Copper to Sandstone

Take 7 parts of white lead, 6 parts of litharge, 6 parts of bole, and 4 parts of broken glass, and rub up with 4 parts of linseed oil varnish.

* * * *

Fire and Waterproof Cement

Mix 10 parts of finely sifted unoxidized iron filings and 5 parts of perfectly dry, pulverized clay, with vinegar spirit, by thoroughly kneading until the whole is a uniform plastic mass. If the cement thus made is used at once, it will harden rapidly and withstand fire and water.

GLUES

To Resist Moisture

Glue, 5 parts; resin, 4 parts; red ochre, 2 parts; mixed with least practicable quantity of water.

Or, glue, 4 parts; boiled oil, 1 part by weight; oxide of iron, 1 part.

Or, glue, 1 pound, melted in two quarts of skimmed milk.

* * * *

Iron and Steel

Clear mastic, 10 parts; camphor, 5 parts; sandarac, 15 parts, and elimi gum, 5 parts. Dissolve in alcohol, filter and apply cold.

* * * *

Marine Glue

1 part of india rubber, 12 parts of mineral naphtha or coal tar. Heat gently, mix, add 20 parts of powder shellac. Pour out on a slab to cool. When used, to be heated to about 250 degrees.

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Shop Wrinkles---Continued

VARNISHES

Iron and Steel

Mercury, 120 parts; tin, 10 parts; green vitriol, 20 parts; hydrochloric acid of 1.2 sp. gr., 15 parts; pure water, 120 parts.

* * * *

To Clean Varnish

Mix a lye of potash or soda with a little powdered chalk.

TO CLEAN BRASS

(U. S. Government Method.) Make a mixture of one part common nitric and one-half part sulphuric acid in a stone jar, having also a pail of fresh water and a box of sawdust. Dip the articles into the acid, then soak them in the water, and finally rub them in the sawdust, and they will take on a brilliant color. If the brass is greasy, it must be first dipped into a strong solution of potash and soda in water, and then rinsed, so that the grease may be removed, leaving the acid free to act.

* * * *

1 part Roche alum and 16 parts water. Mix. The articles to be cleaned must be made warm, then rubbed with the above mixture, and finished with fine tripoli.

TO DRILL HARDENED STEEL

Cover your steel with melted beeswax; when coated and cold, make a hole in the wax with a fine-pointed needle or other article the size of hole you require, put a drop of strong nitric acid upon it; after an hour rinse off and apply again; it will gradually eat through.

A mixture of 1 ounce of sulphate of copper, ¼ ounce of alum, ½ teaspoonful of powdered salt, 1 gill of vinegar and 20 drops of nitric acid will make a hole in steel that is too hard to cut or file easily.

A small hole drilled at the end of a crack in sheet steel will stop it from growing longer.

IN TURNING STEEL OR OTHER HARD METAL

Use a drip composed of two parts petroleum and one part turpentine. This will insure easy cutting and perfect tools when otherwise the work would stop, owing to the breakage of tools from the severe strain.

ANNEALING STEEL

For small pieces of steel, take a piece of gas pipe, 2 or 3 inches in diameter, and put the pieces in it, first heating one end of the pipe, and drawing it together, leaving the other end open to look into. When the pieces are of cherry red, cover the fire with sawdust. Use a charcoal fire and leave the steel in over night.

MIXTURE FOR WELDING STEEL

1 part sal ammoniac, 10 parts borax. Pounded together and fused until clear, when it is poured out, and, after cooling, reduced to powder.

TO TEMPER STEEL VERY HARD

Water, 4 parts; flour, 1 part; salt, 2 parts; mixed to a paste. Heat the steel until a coating adheres when dipped into the mixture; then heat to a cherry red and cool in cold soft water. The steel will come out white and very hard.

TO TEMPER STEEL ON ONE EDGE ONLY

Dip the edge to be tempered into hot lead until proper color; then temper in ordinary fashion.

TO SOFTEN STEEL

Cover with clay, heat to a cherry red in a charcoal fire, and let cool over night in the fire.

CASE HARDENING

Place horn, hoof, bone dust, or shreds of leather, together with the article to be case hardened, in an iron box subject to a blood red heat; then immerse the article in cold water.

* * * *

Case Hardening With Prussiate of Potash

Heat the article, after polishing, to a bright red; rub the surface over with prussiate of potash; allow to cool to dull red and immerse it in water.

* * * *

Case Hardening Mixture

Three parts of potash, one part sal ammoniac; or one part prussiate of potash, two parts sal ammoniac, two parts bone dust.

A SOLDERING ACID THAT WILL SOLDER CAST IRON, STEEL, OR IRON OF ANY KIND. WILL NOT RUST AS OTHER ACIDS

In one pint of muriatic acid, dissolve all the sheet zinc it will take up, then strain off the acid and put in as much concentrated ammonia as will turn the acid white like milk; shake this well and then put in half an ounce of sal ammoniac, half dram spirits of turpentine and three drams of alcohol, shake well and keep corked while not using. This will flow better than any other for soldering.

TO SOLDER WITHOUT HEAT

Brass filings, 2 ounces; steel filings, 2 ounces; fluoric acid ¼ ounce. Put the filings in the acid and apply the solution to the parts to be soldered after thoroughly cleaning the parts in contact, then dress together. Do not keep the fluoric acid in glass bottles, but in lead or earthen vessels.

TO MAKE IRON TAKE A BRIGHT POLISH LIKE STEEL

Pulverize and dissolve the following articles in one quart hot water: blue vitriol, one ounce; borax, one ounce; prussiate of potash, one ounce; charcoal, one ounce; salt, one-half pint; then add one gallon linseed oil; mix well; bring your iron or steel to the proper heat and cool in the solution.

TO SHARPEN DULL FILES

Immerse them in diluted sulphuric acid until cuts are sufficiently deepened.

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Shop Wrinkles---Continued

THAWING FROZEN PIPES

The best way to thaw out a frozen pipe is to take some old discarded clothes, waste, old carpet, or anything of that kind, and lay it on the pipe to be thawed out. Get hot water and pour on it. The cloth will hold the heat to the pipe and thaw it out in five minutes.

MARKING SOLUTION

To give iron or steel a bright copper surface which will show distinctly the lines drawn by scriber, dividers, surface gage, etc., apply a marking solution composed of one ounce of copper sulphate, four ounces of water, and about one teaspoonful of nitric acid. (One ounce is equivalent to about eight teaspoonfuls.) Heating small pieces of steel to a blue will give a similar surface.

DRILLING HOLES THROUGH GLASS

To drill glass, prepare a solution of camphor in turpentine and add some ether. While proportions are not very important, a good solution is made by taking spirits of turpentine 1½ oz., camphor 1 oz., and ether 3 drams. Break the tip from a 3-cornered file so as to have a sharp and very hard point, dip the tip of the file in the solution and give it a twisting motion on the glass where the hole is to be made. Use sufficient pressure to cut the glass but not to break it. Practice will soon enable you to do the trick. Work on odd pieces of glass till you get experience. Be very careful when the tip of the file is about to come through the glass. After the hole is made it can be enlarged to any size by a round file. Keep the glass constantly wet with the solution.

HOW TO WRITE INSCRIPTIONS ON METALS

Take four ounces of nitric acid and one ounce of muriatic acid; mix and shake well together, and it is ready for use. Then cover your metal surface to be engraved with beeswax or soap; write your inscription plainly in the wax clear to the metal; then apply the mixed acids with a feather or stick of wood, carefully filling each letter; let it remain from five to ten minutes, according to appearance desired; then throw on water, which stops the etching process, and the inscription is completed.

TO COPPER IRON OR ZINC

Brine water, three quarts; sulphate of copper, one pound. Mix, immerse the article, and let it remain till the color suits. Then wash and dry in sawdust.

TO CLEAN ZINC

Rub with a piece of cotton cloth dipped in kerosene, afterwards with a dry cloth.

Zinc, if pure, is malleable at 200 degrees; at higher temperatures, such as 400 degrees, it becomes brittle. It is readily acted upon by moist air, and when a film of oxide is formed, it protects the surface from further action. When, however, the air is acid, as from the sea or large towns, it is readily oxidized to destruction.

NOTES ON METALS AND ALLOYS

In manufacture of alloys and compositions, the less fusible metals should be melted first.

* * * *

In composition of brass, as proportion of zinc is increased so is malleability decreased.

* * * *

Tenacity of brass is impaired by addition of lead or tin.

* * * *

Steel alloyed with one five-hundredth part of platinum, or silver, is rendered harder, more malleable, and better adapted for cutting instruments.

* * * *

Solder is an alloy used to make joints between metals. It must be more fusible than the metals it is designed to unite, and is distinguished as hard and soft, according to the temperature of its fusing. The addition of a small portion of bismuth increases its fusibility.

* * * *

Brass is an alloy of copper and zinc, in proportions varying with purpose of metal required, its color depending upon the proportions of the mixture. It is rendered brittle by continued impacts; more malleable than copper when cold, but forging is impracticable, as its zinc melts at a lower temperature. Its fusibility is governed by its proportion of zinc. A small quantity of phosphorus gives it fluidity.

* * * *

Bronze is an alloy of copper and tin; it is harder, more fusible, and stronger than copper. It is generally known as gun-metal.

* * * *

Aluminum bronze contains 90 per cent. to 95 per cent. of copper, and 5 to 10 per cent. aluminum.

* * * *

Phosphor bronze contains copper and tin and a small proportion of phosphorus. It wears better than bronze.

* * * * *

Tin is a white, non-elastic metal, very malleable, and when alloyed with lead it forms pewter and solder; with small proportion of antimony, copper and bismuth, it forms block-tin, britannia, etc.; and united with copper in different proportions, it forms bronze, bell-metal and speculum-metal.

* * * *

Tin is more readily fused than any other metal, and oxidizes very slowly; it fuses at 442 degrees Fahrenheit, and has a specific gravity of 7.3. Its purity is tested by its extreme brittleness at the melting temperature.

* * * *

Tin-plate is iron or steel plate coated with tin; block-tin is tin-plate with an additional coating of tin.

* * * * *

Iron, copper, lead and soot are very destructive of zinc, in consequence of the voltaic action generated, and it should not be in contact with calcareous water or acid woods.

* * * *

The best quality of zinc known is that of "Vielle Montagne," and is composed of zinc, .995; iron, .004; and lead, .001. Its expansion and contraction by difference of temperature is in excess of that of any other metal.

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Shop Wrinkles and Data

TREATMENT AND TEMPERING OF SMALL TOOLS

In the use of chisels, gauges and other tools it is necessary to have these re-tempered continuously. In doing this three operations are necessary:

1. Forging or annealing in order to refine the steel and bring it back to its original condition. Heat in a clear, even fire to a good red heat and forge it to shape with a hammer; as the red color is leaving the steel, refine the cutting edge of the tool with quick light blows from the hammer. Allow the tool to then cool off slowly in the air.

2. Hardening. Heat the cutting end of the tool to a low, red heat. If heated higher, it will open the grain or crystallize the steel. When at the proper temperature, cool off rapidly by plunging into cold water. With small tools it is desirable that the cutting edge only be hardened and that the main portion of the tool be left soft and tough; therefore, only this cutting edge is cooled rapidly in the water.

3. Tempering or making the hard steel lose its brittleness and become tough. Place the hardened tool in the furnace, or on a red hot piece of steel, or in hot oil and bring it up to the temperature required as per table opposite; remove as soon as the color and temperature desired is reached and either cool off quickly or slowly, as it makes no difference. However, when the cutting edge only of small tools is hardened in cold water, the rest of the tool remains very hot; as soon as the cutting edge is cooled, polish with a piece of stone, and the heat from the main portion of the tool is transmitted to the cutting edge, which is tempered as shown by the colors appearing on it. In this case the tool must be plunged into cold water as soon as the proper color is gotten, otherwise heat will continue to be transmitted to the cutting edge, which will thus become brittle.

The slower the tempering is done the better.

HEAT AND TEMPER COLORS OF STEEL PRODUCED BY HEAT

Centigrade Degrees	Fahrenheit Degrees	Colors
215.6	420	Very faint yellow
221.11	430	Very pale yellow
226.67	440	Light yellow
231.11	450	Pale straw yellow
237.78	460	Straw yellow
243.34	470	Deep straw yellow
248.9	480	Dark yellow
254.45	490	Yellow brown
260	500	Brown yellow
265.56	510	Spotted red brown
271.11	520	Brown purple
276.67	530	Light purple
282.23	540	Full purple
287.78	550	Dark purple
293.34	560	Full blue
298.9	570	Dark blue
315.56	600	Very dark blue
400	752	Red Heat—Visible in the dark
474	884	Red Heat—Visible in the twilight
525	977	Red Heat—Visible in the daylight
581	1077	Red Heat—Visible in the sunlight
700	1292	Dark red
800	1472	Dull cherry red
900	1652	Cherry red
1000	1832	Bright cherry red
1100	2012	Orange red
1200	2192	Orange yellow
1300	2372	Yellow white
1400	2552	White welding heat
1500	2732	Brilliant white
1600	2912	Dazzling white (bluish white)

TO SHARPEN REAMERS

Use a stone on face and top of cutting edge, taking care to keep stone perfectly flat.

TABLE SHOWING WEIGHT PER SQUARE FOOT OF DIFFERENT SHEET METALS

Thickness in Fractions of an Inch	Number of Gauge	BIRMINGHAM GAUGE					SPECIAL GAUGES		Number of Gauge
		Decimal of an Inch	Sheet Iron	Steel	Copper	Brass	Sheet Zinc		
							Thickness	Weight	
1/2	..	.500	20.141	20.326	23.125	21.400	.....	.....	..
7/16	..	.437	17.623	17.785	20.234	18.725	.....	.....	..
3/8	..	.375	15.106	15.244	17.344	16.050	.....	.....	..
5/16	..	.312	12.588	12.703	14.453	13.375	.....	.....	..
..	1	.300	12.037	12.198	13.590	12.840	.002	.07	1
..	2	.284	11.395	11.547	12.865	12.155	.004	.15	2
..	3	.259	10.393	10.530	11.732	11.085	.006	.22	3
1/4	..	.250	10.070	10.163	11.562	10.700	.....	.....	..
..	4	.238	9.549	9.677	10.781	10.186	.008	.30	4
..	5	.220	8.827	8.945	9.966	9.416	.010	.37	5
..	6	.203	8.145	8.254	9.195	8.688	.012	.45	6
3/16	..	.187	7.552	7.622	8.672	8.025	.....	.....	..
..	7	.180	7.222	7.318	8.154	7.704	.014	.52	7
..	8	.165	6.620	6.708	7.474	7.062	.016	.60	8
..	9	.148	5.938	6.017	6.704	6.334	.018	.67	9
..	10	.134	5.376	5.448	6.070	5.735	.020	.75	10
1/8	..	.125	5.035	5.081	5.781	5.350	.....	.....	..
..	11	.120	4.815	4.879	5.436	5.136	.024	.90	11
..	12	.109	4.373	4.431	4.937	4.665	.028	1.05	12
..	13	.095	3.811	3.862	4.303	4.066	.032	1.20	13
..	14	.083	3.330	3.374	3.759	3.552	.036	1.35	14
..	15	.072	2.889	2.927	3.261	3.081	.040	1.50	15
..	16	.065	2.608	2.642	2.944	2.782	.045	1.68	16
1/16	..	.062	2.517	2.541	2.890	2.675	.....	.....	..
..	17	.058	2.327	2.358	2.627	2.482	.050	1.87	17
..	18	.049	1.966	1.992	2.219	2.097	.055	2.06	18
..	19	.042	1.685	1.707	1.902	1.797	.060	2.25	19
..	20	.035	1.404	1.423	1.585	1.498	.070	2.62	20
..	21	.032	1.284	1.301	1.449	1.309	.080	3.00	21
..	22	.028	1.123	1.138	1.268	1.198	.090	3.37	22
..	23	.025	1.003	1.016	1.132	1.070	.100	3.75	23
..	24	.022	.882	.894	.996	.941	.125	4.70	24
..	25	.020	.802	.813	.906	.856	.250	9.40	25
..	26	.018	.722	.731	.815	.770	.375	14.00	26
..	27	.016	.642	.650	.724	.684	.500	18.75	27
..	28	.014	.561	.569	.634	.599	1.000	37.50	28
..	29	.013	.521	.528	.588	.556	.....	.....	29
..	30	.012	.481	.487	.543	.513	.....	.....	30
..	31	.010	.401	.406	.453	.428	.....	.....	31
..	32	.009	.361	.365	.407	.385	.....	.....	32

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Shop Wrinkles and Data

TABLE OF RIVETS IN 100 POUNDS

Approximate Number

Length Rivets	Diameter of Rivets 1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	11/16	3/4	7/8	1
1/2	17500	15900	8000	5100	3200	1900	....	....	....	....	....	......
5/8	16000	13800	7000	4500	2900	1800	....	....	....	....	....	....
3/4	14400	12200	6300	4100	2375	1476	1103	642	....	....	....	....
7/8	13500	10900	5700	3700	2190	1371	1030	604	....	....	....	....
1	12600	9800	5200	3400	2084	1280	968	571	400	345	....	....
1 1/8	11600	9000	4700	3100	1898	1200	910	541	382	322	208	....
1 1/4	10800	8300	4400	2900	1780	1129	862	514	365	311	206	....
1 3/8	10000	7600	4100	2700	1675	1066	815	489	350	295	204	....
1 1/2	9300	7100	4000	2500	1582	1010	776	462	335	284	201	....
1 5/8	8700	....	3800	2300	1498	960	740	446	324	275	199	132
1 3/4	8100	6300	3500	2200	1424	914	707	428	311	266	192	128
1 7/8	....	....	3400	2000	1356	872	672	411	302	257	185	124
2	....	5600	3000	1900	1295	834	648	395	298	249	178	120
2 1/8	....	....	....	....	1238	800	623	381	285	240	172	116
2 1/4	....	5000	2800	1800	1187	768	599	367	277	233	167	112
2 3/8	....	....	....	....	1139	738	577	354	269	226	162	108
2 1/2	....	4600	2500	1700	1095	711	556	343	261	219	157	104
2 5/8	....	....	....	....	1052	687	537	332	258	212	152	100
2 3/4	....	4200	2300	1500	1017	662	519	321	245	206	148	96
2 7/8	....	....	....	....	982	636	503	311	237	201	144	92
3	....	3900	2200	1400	949	611	487	302	230	196	140	88
3 1/4	....	3600	2000	1300	890	581	459	285	218	186	132	85
3 1/2	....	3400	1900	1200	837	548	433	270	208	177	126	82
3 3/4	....	3200	1800	1175	791	519	411	257	198	168	120	79
3 7/8	....	....	....	....	....	....	395	250	195	165	119	....
4	....	3000	1700	1100	749	400	390	244	189	161	115	77
4 1/4	....	....	1600	1050	700	....	372	233	180	155	110	75
4 1/2	....	....	1500	1000	650	....	355	223	172	149	105	73
4 3/4	....	....	1475	925	625	....	339	214	166	143	101	71
5	....	....	1400	900	600	....	325	205	160	136	97	69
5 1/4	....	....	1350	850	575	....	312	197	154	131	94	67
5 1/2	....	....	1300	825	550	....	300	190	149	127	91	65
5 3/4	....	....	1250	775	525	....	289	183	144	123	88	63

AVERAGE WEIGHT PER 100 MACHINE BOLTS WITH SQUARE HEADS AND NUTS

Length	Diameter of Bolts 1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4
1 1/2	3.7	6.0	9.0	15.2	19.6	27.5	34.3	54.3	.....	.....	.....	......
2	4.2	7.0	10.5	17.2	22.2	31.0	38.4	60.0	90.8	.....	.....	......
2 1/2	4.8	8.0	12.0	19.2	24.8	34.5	42.5	65.7	99.1	148.2	209.0	277.0
3	5.5	9.0	13.5	21.2	27.5	38.0	46.7	71.4	107.4	159.0	222.5	293.5
3 1/2	6.1	10.0	15.0	23.2	30.1	41.5	50.8	77.1	115.7	169.8	236.6	310.0
4	6.8	11.0	16.5	25.2	32.8	45.0	55.0	82.8	124.0	180.6	249.5	326.5
4 1/2	7.4	12.0	18.0	27.2	35.4	48.5	59.1	88.9	132.3	191.4	263.0	343.0
5	8.1	13.0	19.5	29.2	38.1	52.0	63.8	95.0	140.6	202.2	276.5	359.5
5 1/2	8.7	14.0	21.0	31.2	40.7	55.5	67.4	101.1	148.9	213.0	290.0	376.0
6	9.4	15.0	22.5	33.2	43.4	59.0	71.6	107.2	157.2	223.8	303.5	392.5
6 1/2	10.1	16.0	24.1	35.2	46.0	62.5	75.7	113.3	165.5	234.6	317.0	409.0
7	10.8	17.0	25.7	37.2	48.7	66.0	79.9	119.4	173.8	245.8	330.5	425.5
7 1/2	11.5	18.0	27.3	39.2	51.3	69.5	84.0	125.5	182.1	256.2	344.0	442.0
8	12.2	19.0	28.9	41.2	54.0	73.0	88.2	131.6	190.4	267.0	357.5	458.5
9	....	....	32.1	45.2	59.5	80.0	96.5	143.8	207.0	288.6	385.5	493.0
10	....	....	35.3	49.2	65.0	87.0	104.8	156.0	223.6	310.2	413.5	527.5
11	....	....	38.5	53.2	70.5	94.0	113.1	168.2	240.2	331.8	441.5	562.0
12	....	....	41.7	57.2	76.0	101.0	121.4	180.4	256.8	353.4	469.5	596.5
13	....	....	....	....	81.5	108.0	129.7	192.6	273.4	375.0	497.5	631.0
14	....	....	....	....	87.0	115.0	138.0	204.8	290.0	396.6	525.5	665.5
15	....	....	....	....	92.5	122.0	146.3	217.0	306.6	418.2	553.5	700.0
16	....	....	....	....	98.0	129.0	154.6	229.2	323.2	439.8	581.5	734.5
17	....	....	....	....	103.5	136.0	162.9	241.4	339.8	461.4	609.5	769.0
18	....	....	....	....	109.0	143.0	171.2	253.6	356.4	483.0	637.5	803.5
19	....	....	....	....	114.5	150.0	179.5	265.8	373.0	504.6	665.5	838.0
20	....	....	....	....	120.0	157.0	187.8	278.0	389.6	526.2	693.5	872.5
21	....	....	....	....	125.0	164.0	196.1	290.4	406.5	548.2	721.5	907.0
22	....	....	....	....	131.0	171.0	204.4	302.8	423.4	570.2	749.5	941.5
23	....	....	....	....	136.5	178.0	212.7	315.2	440.3	592.2	777.5	976.0
24	....	....	....	....	142.0	185.0	221.0	327.6	457.2	614.2	805.5	1010.5
25	....	....	....	....	147.5	192.0	229.3	340.0	474.1	636.2	833.5	1045.0
26	....	....	....	....	153.0	199.0	237.6	352.4	491.0	658.2	861.5	1079.5
27	....	....	....	....	158.5	206.0	245.9	364.8	507.9	680.2	889.5	1114.0
28	....	....	....	....	164.0	213.0	254.2	377.2	524.8	702.2	917.5	1148.5
29	....	....	....	....	169.5	220.0	262.5	389.6	541.7	724.2	945.5	1183.0
30	....	....	....	....	175.0	227.0	270.8	402.0	558.6	746.2	973.5	1217.5

STRENGTH OF WROUGHT IRON BOLTS

Diameter of Bolt in Inches	Safe Load in Pounds
1/2	1000
5/8	1800
3/4	2750
1	5000
1 1/8	6250
1 1/4	8050
1 3/8	10000
1 1/2	11800
1 3/4	15750
2	20800

A Solvent for Rust

It is often very difficult and sometimes impossible to remove rust from articles made of iron. Those which are most thickly coated are most easily cleaned by being immersed in a solution, nearly saturated, of chloride of tin. The length of time they remain in this bath is determined by the thickness of the coating of rust. Generally 12 to 24 hours is long enough. The solution ought not to contain a great excess of acid, if the iron itself is not attacked. On taking them from the bath the articles are rinsed, first in water, then in ammonia, and quickly dried. The iron, when thus treated, has the appearance of dull silver. A simple polishing gives it its normal appearance.

* * * *

To Loosen a Screw Rusted in Iron or Wood

Heat a piece of iron and then place it against the head of the screw; the heat will cause the screw to expand and break the rust, let it cool off, and the screw will contract again, and will then be easily removed.

* * * *

To Keep Machinery From Rusting

Take one ounce of camphor; dissolve it in one pound of melted lard; take off the scum, and mix in as much fine black lead as will give it iron color. Clean the machinery and smear it with this mixture. After 24 hours, rub clean with a soft linen cloth. It will keep clean for months under ordinary circumstances.

* * * *

To Preserve Steel From Rust

1 part caoutchouc, 16 parts turpentine. Dissolve with a gentle heat, then add 8 parts boiled oil. Mix by bringing them to the heat of boiling water; apply to the steel with a brush, in the way of varnish. It may be removed with turpentine.

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Shop Data

WEIGHT OF FLAT IRON PER LINEAL FOOT IN POUNDS

Width in Inches	THICKNESS IN INCHES											
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
1	.21	.42	.63	.84	1.05	1.26	1.47	1.68	2.11	2.53	....	....
1 1/8	.24	.47	.71	.95	1.18	1.42	1.66	1.90	2.37	2.84	....	....
1 1/4	.26	.53	.79	1.05	1.32	1.58	1.84	2.11	2.63	3.16	3.68	4.21
1 3/8	.29	.58	.87	1.16	1.45	1.74	2.03	2.32	2.89	3.47	4.05	4.63
1 1/2	.32	.63	.95	1.26	1.58	1.90	2.21	2.53	3.16	3.79	4.42	5.05
1 5/8	.34	.68	1.03	1.37	1.71	2.05	2.39	2.74	3.42	4.11	4.79	5.47
1 3/4	.37	.74	1.11	1.47	1.84	2.21	2.58	2.95	3.68	4.42	5.16	5.89
2	.42	.84	1.26	1.68	2.11	2.53	2.95	3.37	4.21	5.05	5.89	6.74
2 1/4	.47	.95	1.42	1.90	2.37	2.84	3.32	3.79	4.74	5.68	6.63	7.58
2 1/2	.53	1.05	1.58	2.11	2.63	3.16	3.68	4.21	5.26	6.32	7.37	8.42
2 3/4	.58	1.16	1.74	2.32	2.89	3.47	4.05	4.63	5.79	6.95	8.10	9.26
3	.63	1.26	1.90	2.53	3.16	3.79	4.42	5.05	6.32	7.58	8.84	10.10
3 1/4	.68	1.37	2.05	2.74	3.42	4.11	4.79	5.47	6.84	8.21	9.58	10.95
3 1/2	.74	1.47	2.21	2.95	3.68	4.42	5.16	5.89	7.37	8.84	10.32	11.79
3 3/4	.79	1.58	2.37	3.16	3.95	4.74	5.53	6.32	7.89	9.47	11.05	12.63
4	.84	1.68	2.53	3.37	4.21	5.05	5.89	6.74	8.42	10.10	11.79	13.47
4 1/2	.95	1.90	2.84	3.79	4.74	5.68	6.63	7.58	9.47	11.38	13.26	15.16
5	1.05	2.11	3.16	4.21	5.26	6.32	7.37	8.42	10.53	12.63	14.74	16.84
5 1/2	1.16	2.32	3.47	4.63	5.79	6.95	8.10	9.26	11.58	13.89	16.21	18.52
6	1.26	2.53	3.79	5.05	6.32	7.58	8.84	10.10	12.63	15.16	17.68	20.21
7	1.47	2.94	4.42	5.90	7.36	8.84	10.32	11.79	14.74	17.68	20.64	23.58
8	1.68	3.36	5.05	6.74	8.42	10.10	11.78	13.48	16.84	20.20	23.58	26.94

For steel about 2 per cent. should be added to the weight.

WEIGHT AND SPECIFIC GRAVITY OF METALS

	Weight Per Cu. Ft. Lbs.	Weight Per Cu. In. Lbs.	Specific Gravity		Weight Per Cu. Ft. Lbs.	Weight Per Cu. In. Lbs.	Specific Gravity
Aluminum	163	.094	2.583	Iron, wrought	485	.280	7.78
Aluminum, cast	419	.242	6.72	Lead, cast	708	.410	11.36
Bismuth	611	.353	9.822	Lead, rolled	711	.411	11.41
Brass	524	.300	8.40	Mercury	849	.492	13.596
Bronze	534	.300	8.561	Platinum	1344	.778	21.531
Copper, cast	537	.310	8.607	Platinum, sheet	1436	.332	23.000
Copper, wire	555	.320	8.9	Silver, pure	654	.379	10.474
Gold, 24 carat	1308	.697	19.361	Silver, standard	644	.372	10.312
Gold, standard	1106	.638	17.724	Steel	490	.284	7.85
Gun Metal	528	.304	8.459	Tin, cast	455	.263	7.291
Iron, cast	450	.260	7.21	Zinc	437	.252	7.1

METALS—WEIGHT PER SQUARE FOOT IN POUNDS
Thickness, Inches

	1/16	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1
Wrought Iron	2.53	5.05	10.10	15.16	20.21	25.27	30.31	35.37	40.42
Cast Iron	2.34	4.69	9.38	14.06	18.75	23.44	28.13	32.81	37.50
Steel	2.55	5.10	10.21	15.31	20.42	25.52	30.63	35.73	40.83
Copper	2.89	5.78	11.56	17.34	23.13	28.91	34.69	40.47	46.25
Brass	2.73	5.47	10.94	16.41	21.88	27.34	32.81	38.28	43.75
Lead	3.71	7.42	14.83	22.25	29.67	37.08	44.50	51.92	59.33
Zinc	2.34	4.69	9.38	14.06	18.75	23.44	28.13	32.81	37.50

WEIGHTS OF SQUARE AND ROUND BARS OF WROUGHT IRON
In Pounds Per Lineal Foot—Kent

Thickness or Diameter in Inches	Weight of Square Bar One Foot Long	Weight of Round Bar One Foot Long	Thickness or Diameter in Inches	Weight of Square Bar One Foot Long	Weight of Round Bar One Foot Long	Thickness or Diameter in Inches	Weight of Square Bar One Foot Long	Weight of Round Bar One Foot Long
0			2	13.33	10.47	4	53.33	41.89
1/16	.013	.010	1/16	14.18	11.14	1/16	55.01	43.21
1/8	.052	.041	1/8	15.05	11.82	1/8	56.72	44.55
3/16	.117	.092	3/16	15.95	12.53	3/16	58.45	45.91
1/4	.208	.164	1/4	16.88	13.25	1/4	60.21	47.29
5/16	.326	.256	5/16	17.83	14.00	5/16	61.99	48.69
3/8	.469	.368	3/8	18.80	14.77	3/8	63.80	50.11
7/16	.638	.501	7/16	19.80	15.55	7/16	65.64	51.55
1/2	.833	.654	1/2	20.83	16.36	1/2	67.50	53.01
9/16	1.055	.828	9/16	21.89	17.19	9/16	69.39	54.50
5/8	1.302	1.023	5/8	22.97	18.04	5/8	71.30	56.00
11/16	1.576	1.237	11/16	24.08	18.91	11/16	73.24	57.52
3/4	1.875	1.473	3/4	25.21	19.80	3/4	75.21	59.07
13/16	2.201	1.728	13/16	26.37	20.71	13/16	77.20	60.63
7/8	2.552	2.004	7/8	27.55	21.64	7/8	79.22	62.22
15/16	2.930	2.301	15/16	28.76	22.59	15/16	81.26	63.82
1	3.333	2.618	3	30.00	23.56	5	83.33	65.45
1/16	3.763	2.955	1/16	31.26	24.55	1/16	85.43	67.10
1/8	4.219	3.313	1/8	32.55	25.57	1/8	87.55	68.76
3/16	4.701	3.692	3/16	33.87	26.60	3/16	89.70	70.45
1/4	5.208	4.091	1/4	35.21	27.65	1/4	91.88	72.16
5/16	5.742	4.510	5/16	36.58	28.73	5/16	94.08	73.89
3/8	6.302	4.950	3/8	37.97	29.82	3/8	96.30	75.64
7/16	6.888	5.410	7/16	39.39	30.94	7/16	98.55	77.40
1/2	7.500	5.890	1/2	40.83	32.07	1/2	100.8	79.19
9/16	8.138	6.392	9/16	42.30	33.23	9/16	103.1	81.00
5/8	8.802	6.913	5/8	43.80	34.40	5/8	105.5	82.83
11/16	9.492	7.455	11/16	45.33	35.60	11/16	107.8	84.69
3/4	10.21	8.018	3/4	46.88	36.82	3/4	110.2	86.56
13/16	10.95	8.601	13/16	48.45	38.05	13/16	112.6	88.45
7/8	11.72	8.204	7/8	50.05	39.31	7/8	115.1	90.36
15/16	12.51	9.828	15/16	51.68	40.59	15/16	117.5	92.29
						6	120.0	94.25

Table based on iron weighing 480 pounds per cubic foot. For steel add 2 per cent.

EXPANSION AND CONTRACTION

Scarcely anything can withstand the expansion of iron. It expands from 32° to 212°, about 1/900 of its length, which in 100 feet equals 1⅜ inches. The expanding power of a 2″ pipe when heated to a temperature of 100 pounds steam, or to 338°, exerts a force sufficient to move 25 tons.

Cast iron expands 1/162,000 of its length for each degree Fahrenheit.

Wrought iron expands 1/150000 of its length for each degree Fahrenheit. To find the expansion of a line of pipe multiply its length in inches by the number of degrees of temperature applied and divide the product by 150,000 for required expansion in inches: thus 100′×12″=1200 × 338° = 405600 ÷ 150000 =2.7 inches.

Special attention, then, must be given to the expansion and contraction of pipes and allowance made for it. Pipes and branches must be unconfined, especially in the direction of their length.

Expansion joints should not be used if the expansion can be compensated for in any other way.

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COMPARATIVE TABLE
Weight of Galvanized Sheets

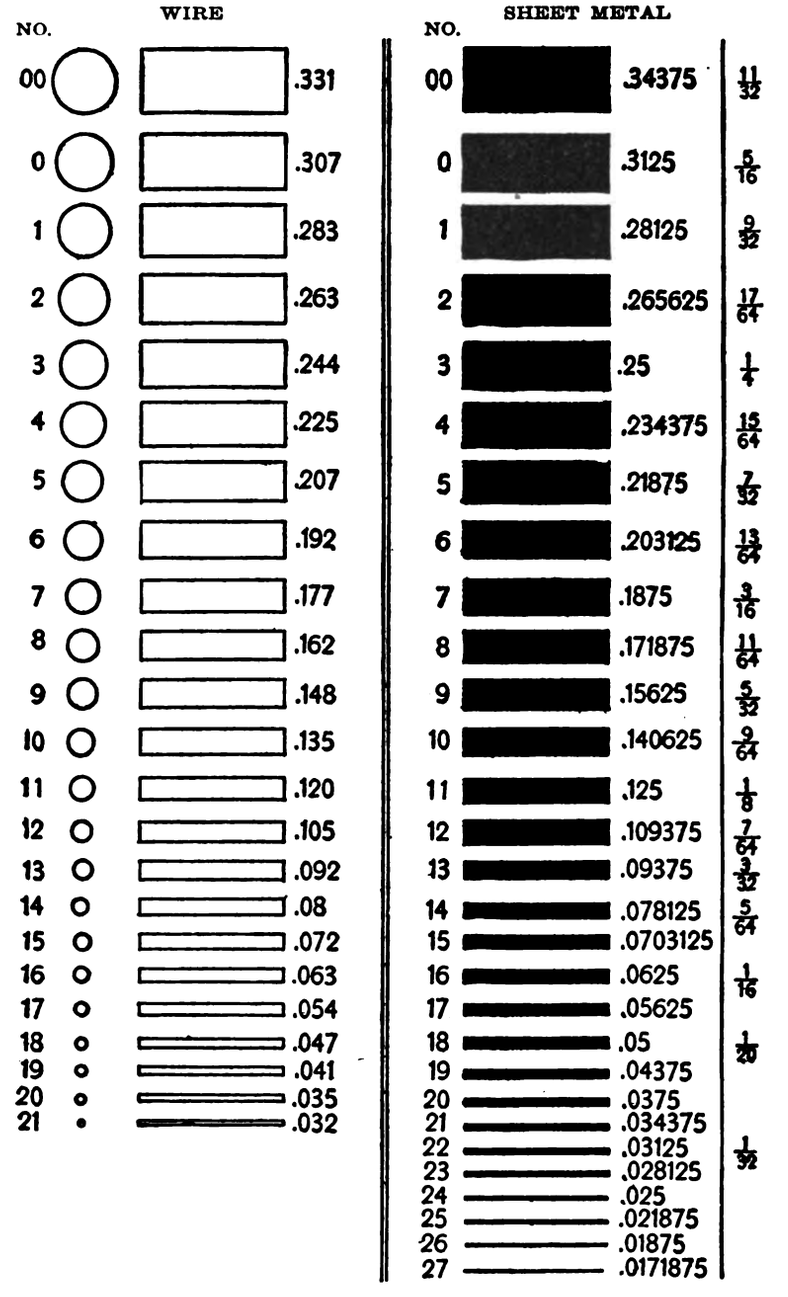
U. S. Standard Gauge	10	12	14	16	18	20	22	24	25	26	27	28	29	30
Weight per sq. ft., lbs.	5.781	4.531	3.281	2.656	2.156	1.656	1.406	1.156	1.031	.9062	.8437	.7812	.7187	.6562
Weight per sq. ft., oz.	92.5	72.5	52.5	42.5	34.5	26.5	22.5	18.5	16.5	14.5	13.5	12.5	11.5	10.5

Size of Sheet	Weight of Sheet—Pounds													
24 x 72	69	54	39	32	26	20	17	14	12	11	10	9	9	8
24 x 84	81	63	46	37	30	23	20	16	14	13	12	11	10	9
24 x 96	93	73	53	43	35	27	23	19	17	15	14	13	12	11
24 x 120	116	91	66	53	43	33	28	23	21	18	17	16	14	13
26 x 72	75	59	43	35	28	22	18	15	13	12	11	10	9	9
26 x 84	88	69	50	40	33	25	21	18	16	14	13	12	11	10
26 x 96	100	79	57	46	37	29	24	20	18	16	15	14	12	11
26 x 120	125	98	71	58	47	36	30	25	22	20	18	17	16	14
28 x 72	81	63	46	37	30	23	20	16	14	13	12	11	10	9
28 x 84	94	74	54	43	35	27	23	19	17	15	14	13	12	11
28 x 96	108	85	61	50	40	31	26	22	19	17	16	15	13	12
28 x 120	135	106	77	62	50	39	33	27	24	21	20	18	17	15
30 x 72	87	68	49	40	32	25	21	17	15	14	13	12	11	10
30 x 84	101	79	57	46	38	29	25	20	18	16	15	14	13	11
30 x 96	116	91	66	53	43	33	28	23	21	18	17	16	14	13
30 x 120	145	113	82	66	54	41	35	29	26	23	21	20	18	16
36 x 72	104	82	59	48	39	30	25	21	19	16	15	14	13	12
36 x 84	121	95	69	55	45	35	30	24	22	19	18	16	15	14
36 x 96	139	109	79	64	52	40	34	28	25	22	20	19	17	16
36 x 120	173	136	98	80	65	50	42	35	31	27	25	23	22	20
42 x 72	121	95	71	56	45	34	29	24	22	19	18	16	15	14
42 x 84	142	111	80	65	53	41	34	28	25	22	21	19	18	16
42 x 96	162	127	92	74	60	46	39	32	29	25	24	22	20	18
42 x 120	202	159	115	93	75	58	49	41	36	33	29	27	25	23
48 x 72	139	109	79	64	52	40	34	28	25	22	20	19	17	16
48 x 84	162	125	92	74	60	46	39	32	29	25	24	22	20	18
48 x 96	185	145	105	85	69	55	45	37	33	29	27	25	23	21
48 x 120	231	181	131	106	86	66	56	46	41	36	34	31	29	..

WIRE
Weight of 100 Lineal Feet

B. W. Gauge	Iron	Steel	Brass	Copper
0	30.58	30.92	33.43	35.17
1	25.75	26.04	28.15	29.62
2	21.34	21.57	23.32	24.54
3	18.02	18.22	19.70	20.72
4	15.11	15.28	16.52	17.38
5	12.46	12.59	13.62	14.33
6	11.45	11.57	12.51	13.16
7	9.25	9.35	10.11	10.64
8	7.29	7.37	7.97	8.38
9	6.60	6.68	7.22	7.59
10	4.96	5.02	5.43	5.71
11	4.13	4.18	4.52	4.75
12	3.14	3.18	3.43	3.61
13	2.34	2.36	2.55	2.69
14	1.69	1.71	1.85	1.95
15	1.37	1.39	1.50	1.58
16	1.05	1.06	1.15	1.21
17	.804	.815	.877	.928
18	.612	.622	.674	.704
19	.471	.478	.510	.547
20	.326	.331	.342	.372
21	.271	.274	.293	.310
22	.208	.210	.224	.237
23	.166	.167	.179	.189
24	.128	.129	.138	.147
25	.106	.107	.114	.121
26	.086	.087	.093	.098
27	.068	.069	.073	.078
28	.052	.053	.056	.059
29	.045	.046	.048	.051
30	.038	.039	.041	.044

DIAGRAM SHOWING ACTUAL SIZES OF U. S. GAGE



SHRINKAGE OF CASTINGS

Pattern maker's rule should be for { Cast iron... 1/8; Brass ..... 3/16; Lead ..... 1/8; Tin ..... 1/12; Zinc ..... 3/16 } of an inch longer per linear foot

TO COMPUTE WEIGHTS OF DIFFERENT MATERIALS

Sheets

Steel—Divide the thickness, expressed in thousandths, by 25. The result is the weight in pounds per square foot.

Brass—Add 11 per cent. to the weight of sheet steel.

Copper—Add 10 per cent. to the weight of sheet steel.

Bars and Plates

Iron—Multiply contents in cubic inches by .27777. Result will be weight in pounds.

Steel—Multiply contents in cubic inches by .28332. Result will be weight in pounds.

Copper—Multiply contents in cubic inches by .32118. Result will be weight in pounds.

Brass—Multiply contents in cubic inches by .3112. Result will be weight in pounds.

Lead—Multiply contents in cubic inches by .41015. Result will be weight in pounds.

Zinc—Multiply contents in cubic inches by .25318. Result will be weight in pounds.

Tin—Multiply contents in cubic inches by .26562. Result will be weight in pounds.

Aluminum—Multiply contents in cubic inches by .09375. Result will be weight in pounds.

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U. S. STANDARD SCREW THREADS

Diameter	Threads per Inch	Diameter of Root of Thread	Width of Flat	Area of Bolt Body	Area at Root of Thread	Short Diameter of Nut, Rough	Short Diameter of Nut, Finished	Long Diameter of Hex. Nut, Rough	Long Diameter of Square Nut, Rough	Thickness of Nut, Rough	Thickness of Nut, Finish
Inches		Inches	Inches	Square Inches	Square Inches	Inches	Inches	Inches	Inches	Inches	Inches
1/4	20	.185	.0062	.049	.027	1/2	7/16	37/64	7/10	1/4	3/16
5/16	18	.240	.0074	.077	.045	19/32	17/32	11/16	10/12	5/16	1/4
3/8	16	.294	.0078	.110	.068	11/16	5/8	51/64	63/64	3/8	5/16
7/16	14	.344	.0089	.150	.093	25/32	23/32	9/10	1 7/64	7/16	3/8
1/2	13	.400	.0096	.196	.126	7/8	13/16	1	1 15/64	1/2	7/16
9/16	12	.454	.0104	.249	.162	31/32	29/32	1 1/8	1 23/64	9/16	1/2
5/8	11	.507	.0113	.307	.202	1 1/16	1	1 7/32	1 1/2	5/8	9/16
3/4	10	.620	.0125	.442	.302	1 1/4	1 3/16	1 7/16	1 49/64	3/4	11/16
7/8	9	.731	.0138	.601	.420	1 7/16	1 3/8	1 21/32	2 1/32	7/8	13/16
1	8	.837	.0156	.785	.550	1 5/8	1 9/16	1 7/8	2 19/64	1	15/16
1 1/8	7	.940	.0178	.994	.694	1 13/16	1 3/4	2 3/32	2 9/16	1 1/8	1 1/16
1 1/4	7	1.065	.0178	1.227	.893	2	1 15/16	2 5/16	2 53/64	1 1/4	1 3/16
1 3/8	6	1.160	.0208	1.485	1.057	2 3/16	2 1/8	2 17/32	3 3/32	1 3/8	1 5/16
1 1/2	6	1.284	.0208	1.767	1.295	2 3/8	2 5/16	2 3/4	3 23/64	1 1/2	1 7/16
1 5/8	5 1/2	1.389	.0227	2.074	1.515	2 9/16	2 1/2	2 31/32	3 5/8	1 5/8	1 9/16
1 3/4	5	1.491	.0250	2.405	1.746	2 3/4	2 11/16	3 3/16	3 57/64	1 3/4	1 11/16
1 7/8	5	1.616	.0250	2.761	2.051	2 15/16	2 7/8	3 13/32	4 5/32	1 7/8	1 13/16
2	4 1/2	1.712	.0277	3.142	2.302	3 1/8	3 1/16	3 5/8	4 27/64	2	1 15/16
2 1/4	4 1/2	1.962	.0277	3 976	3.023	3 1/2	3 7/16	4 1/16	4 61/64	2 1/4	2 3/16
2 1/2	4	2.176	.0312	4.909	3.719	3 7/8	3 13/16	4 1/2	5 31/64	2 1/2	2 7/16
2 3/4	4	2.426	.0312	5.940	4.620	4 1/4	4 3/16	4 29/32	6	2 3/4	2 11/16
3	3 1/2	2.629	.0357	7.069	5.428	4 5/8	4 9/16	5 3/8	6 17/32	3	2 15/16
3 1/4	3 1/2	2.879	.0357	8.296	6.510	5	4 15/16	5 13/16	7 1/16	3 1/4	3 3/16
3 1/2	3 1/4	3.100	.0384	9.621	7.548	5 3/8	5 5/16	6 7/64	7 39/64	3 1/2	2 7/16
3 3/4	3	3.317	.0413	11.045	8.641	5 3/4	5 11/16	6 21/32	8 1/8	3 3/4	3 11/16
4	3	3.567	.0413	12.566	9.963	6 1/8	6 1/16	7 3/32	8 41/16	4	3 15/16
4 1/4	2 7/8	3.798	.0435	14.186	11.329	6 1/2	6 7/16	7 9/16	9 3/16	4 1/4	4 3/16
4 1/2	2 3/4	4.028	.0454	15.904	12.753	6 7/8	6 13/16	7 31/32	9 3/4	4 1/2	4 7/16
4 3/4	2 5/8	4.256	.0476	17.721	14.226	7 1/4	7 3/16	8 13/32	10 1/4	4 3/4	4 11/16
5	2 1 2	4.480	.0500	19.635	15.763	7 5/8	7 9/16	8 27/32	10 49/64	5	4 15/16
5 1/4	2 1/2	4.730	.0500	21.648	17.572	8	7 15/16	9 9/32	11 23/64	5 1/4	5 3/16
5 1/2	2 3/8	4.953	.0526	23.758	19.267	8 3/8	8 5/16	9 23/32	11 7/8	5 1/2	5 7/16
5 3/4	2 3/8	5.203	.0526	25.967	21.262	8 3/4	8 11/16	10 5/32	12 3/8	5 3/4	5 11/16
6	2 1/4	5.423	.0555	28.274	23.098	9 1/8	9 1/16	10 19/32	12 15/16	6	5 15/16

WEIGHT OF COMMON CARRIAGE BOLTS WITH SQUARE NUTS

Table Showing the Average Weight in Pounds of 100 Common Carriage Bolts of Sizes Enumerated

Diameter	1/4	5/16	3/8	7/16	1/2	5/8	3/4
Length in Inches	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	2.6	4.6	7.1	10.8	14.5	27.1	....
1½	3.2	5.6	8.5	12.8	17.1	31.2	....
2	3.9	6.5	10.0	14.7	19.6	35.3	....
2½	4.5	7.5	11.4	16.7	22.2	39.4	58.4
3	5.2	8.4	12.9	18.6	24.7	43.5	64.4
3½	5.8	9.4	14.3	20.6	27.3	47.6	70.3
4	6.5	10.3	15.8	22.5	29.8	51.7	76.3
4½	7.1	11.3	17.2	24.5	32.4	55.8	82.2
5	7.8	12.2	18.7	26.4	34.9	59.9	88.2
5½	8.4	13.2	20.1	28.4	37.5	64.0	94.1
6	9.1	14.1	21.6	30.3	40.0	68.1	100.1
6½	9.7	15.1	23.0	32.3	42.6	72.2	106.0
7	10.4	16.0	24.5	34.2	45.1	76.3	112.0
7½	11.0	17.0	25.9	36.2	47.7	80.4	117.9
8	11.7	17.9	27.4	38.1	50.2	84.5	123.9
8½	12.3	18.9	28.8	40.1	52.8	88.6	129.8
9	13.0	19.8	30.3	42.0	55.3	92.7	135.8
9½	13.6	20.8	31.7	44.0	57.9	96.8	141.7
10	14.3	21.7	33.2	45.9	60.4	100.9	147.7
10½	14.9	22.7	34.6	47.9	63.0	105.0	153.6
11	15.6	23.6	36.1	49.8	65.5	109.1	159.6
11½	16.2	24.6	37.5	51.8	68.1	113.2	165.5
12	16.9	25.5	39.0	53.7	70.6	117.3	171.5

U. S. STANDARD SYSTEM OF BOLTS AND NUTS

As Recommended by the Franklin Institute

Diameter of Bolt	Number of Threads per Inch	Diameter of Hole in Nut	Short Diameter of Nut
1/4 "	20	.185	1/2 "
5/16"	18	.240	19/32"
3/8 "	16	.294	11/16"
7/16"	14	.344	25/32"
1/2 "	13	.400	7/8 "
9/16"	12	.454	31/32"
5/8 "	11	.507	1 1/16"
3/4 "	10	.620	1 1/4 "
7/8 "	9	.731	1 7/16"
1 "	8	.837	1 5/8 "
1 1/8 "	7	.940	1 13/16"
1 1/4 "	7	1.065	2 "
1 3/8 "	6	1.060	2 3/16"
1 1/2 "	6	1.284	2 3/8 "
1 5/8 "	5 1/2	1.389	2 9/16"
1 3/4 "	5	1.490	2 3/4 "
1 7/8 "	5	1.615	2 15/16"
2 "	4 1/2	1.712	3 1/8 "
2 1/4 "	4 1/2	1.962	3 1/2 "
2 1/2 "	4	2.175	3 7/8 "
2 3/4 "	4	2.425	4 1/4 "
3 "	3 1/2	2.628	4 5/8 "
3 1/4 "	3 1/2	2.878	5 "
3 1/2 "	3 1/4	3.100	5 3/8 "
3 3/4 "	3	3.317	5 3/4 "
4 "	3	3.566	6 1/8 "
4 1/4 "	2 7/8	3.825	6 1/2 "
4 1/2 "	2 3/4	4.027	6 7/8 "
4 3/4 "	2 5/8	4.255	7 1/4 "
5 "	2 1/2	4.480	7 5/8 "
5 1/4 "	2 1/2	4.730	8 "
5 1/2 "	2 3/8	5.053	8 3/8 "
5 3/4 "	2 3/8	5.203	8 3/4 "
6 "	2 1/4	5.423	9 1/8 "

CONTENTS FULL KEGS MACHINE BOLTS

Length Inches	Diam. ⅜ in.	Diam. ½ in.	Diam. ⅝ in.	Diam. ¾ in.	Diam. ⅞ in.	Diam. 1 in.
1	3000	1300	750	500	250	...
1½	2600	1200	700	475	250	...
1¾	2500	1100	700	425	250	...
2	2400	1000	575	400	250	200
2¼	2200	950	550	375	200	175
2½	2000	900	525	350	200	175
2¾	1800	850	475	325	175	150
3	1700	800	450	300	175	125
3¼	1600	700	425	275	175	125
3½	1500	650	400	275	175	125
3¾	1400	625	375	250	175	100
4	1400	600	350	250	175	100
4¼	....	575	325	225	150	100
4½	1100	550	325	225	150	100
4¾	....	525	300	200	150	90
5	900	500	300	200	125	80
5½	....	450	275	200	125	75
6	....	425	275	175	100	75
6½	....	400	250	175	100	...
7	....	375	250	175	100	...
7½	....	350	225	150	...	...
8	....	350	225	150	...	...

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DECIMALS AND FRACTIONS—INCH AND FOOT

Frac. of Foot	Decimal Part of Foot	Inch Equivalents to Foot Fractions	Frac. of Foot	Decimal Part of Foot	Inch Equivalents to Foot Fractions	Frac. of Foot	Decimal Part of Foot	Inch Equivalents to Foot Fractions	Frac. of Foot	Decimal Part of Foot	Inch Equivalents to Foot Fractions
	.0052	1/16		.2552	3 1/16		.5052	6 1/16		.7552	9 1/16
	.0104	1/8		.2604	3 1/8		.5104	6 1/8		.7604	9 1/8
1/64	.015625	3/16	33/64	.265625	3 3/16	33/64	.515625	6 3/16	33/64	.765625	9 3/16
	.0208	1/4		.2708	3 1/4		.5208	6 1/4		.7708	9 1/4
	.0260	5/16		.2760	3 5/16		.5260	6 5/16		.7760	9 5/16
1/32	.03125	3/8	17/32	.28125	3 3/8	17/32	.53125	6 3/8	17/32	78125	9 3/8
	.0365	7/16		.2865	3 7/16		.5365	6 7/16		.7865	9 7/16
	.0417	1/2		.2917	3 1/2		.5417	6 1/2		.7917	9 1/2
3/64	.046875	9/16	35/64	.296875	3 9/16	35/64	.546875	6 9/16	35/64	.796875	9 9/16
	.0521	5/8		.3021	3 5/8		.5521	6 5/8		.8021	9 5/8
	.0573	11/16		.3073	3 11/16		.5573	6 11/16		.8073	9 11/16
1/16	.0625	3/4	9/16	.3125	3 3/4	9/16	.5625	6 3/4	9/16	.8125	9 3/4
	.0677	13/16		.3177	3 13/16		.5677	6 13/16		.8177	9 13/16
	.0729	7/8		.3229	3 7/8		.5729	6 7/8		.8229	9 7/8
5/64	.078125	15/16	37/64	.328125	3 15/16	37/64	.578125	6 15/16	37/64	.828125	9 15/16
	.0833	1		.3333	4		.5833	7		.8333	10
	.0885	1 1/16		.3385	4 1/16		.5885	7 1/16		.8385	10 1/16
3/32	.09375	1 1/8	19/32	.34375	4 1/8	19/32	.59375	7 1/8	19/32	.84375	10 1/8
	.0990	1 3/16		.3490	4 3/16		.5990	7 3/16		.8490	10 3/16
	.1042	1 1/4		.3542	4 1/4		.6042	7 1/4		.8542	10 1/4
7/64	.109375	1 5/16	39/64	.359375	4 5/16	39/64	.609375	7 5/16	39/64	.859375	10 5/16
	.1146	1 3/8		.3646	4 3/8		.6146	7 3/8		.8646	10 3/8
	.1198	1 7/16		.3698	4 7/16		.6198	7 7/16		.8698	10 7/16
1/8	.1250	1 1/2	5/8	.3750	4 1/2	5/8	.6250	7 1/2	7/8	.8750	10 1/2
	.1302	1 9/16		.3802	4 9/16		.6302	7 9/16		.8802	10 9/16
	.1354	1 5/8		.3854	4 5/8		.6354	7 5/8		.8854	10 5/8
9/64	.140625	1 11/16	41/64	.390625	4 11/16	41/64	.640625	7 11/16	41/64	.890625	10 11/16
	.1458	1 3/4		.3958	4 3/4		.6458	7 3/4		.8958	10 3/4
	.1510	1 13/16		.4010	4 13/16		.6510	7 13/16		.9010	10 13/16
5/32	.15625	1 7/8	21/32	.40625	4 7/8	21/32	.65625	7 7/8	21/32	.90625	10 7/8
	.1615	1 13/16		.4115	4 13/16		.6615	7 13/16		.9115	10 13/16
	.1667	2		.4167	5		.6667	8		.9167	11
11/64	.171875	2 1/16	43/64	.421875	5 1/16	43/64	.671875	8 1/16	43/64	.921875	11 1/16
	.1771	2 1/8		.4271	5 1/8		.6771	8 1/8		.9271	11 1/8
	.1823	2 3/16		.4323	5 3/16		.6823	8 3/16		.9323	11 3/16
3/16	.1875	2 1/4	11/16	.4375	5 1/4	11/16	.6875	8 1/4	11/16	.9375	11 1/4
	.1927	2 5/16		.4427	5 5/16		.6927	8 5/16		.9427	11 5/16
	.1979	2 3/8		.4479	5 3/8		.6979	8 3/8		.9479	11 3/8
13/64	.203125	2 7/16	45/64	.453125	5 7/16	45/64	.703125	8 7/16	45/64	.953125	11 7/16
	.2083	2 1/2		.4583	5 1/2		.7083	8 1/2		.9583	11 1/2
	.2135	2 9/16		.4635	5 9/16		.7135	8 9/16		.9635	11 9/16
7/32	.21875	2 5/8	23/32	.46875	5 5/8	23/32	.71875	8 5/8	23/32	.96875	11 5/8
	.2240	2 11/16		.4740	5 11/16		.7240	8 11/16		.9740	11 11/16
	.2292	2 3/4		.4792	5 3/4		.7292	8 3/4		.9792	11 3/4
15/64	.234375	2 13/16	47/64	.484875	5 13/16	47/64	.734375	8 13/16	47/64	.984375	11 13/16
	.2396	2 7/8		.4896	5 7/8		.7396	8 7/8		.9896	11 7/8
	.2448	2 15/16		.4948	5 15/16		.7448	8 15/16		.9948	11 15/16
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12

ALLOYS AND COMPOSITIONS

There does not appear to be any standard rule among founders for alloys and compositions. The mixtures vary in proportion to the price and the purpose of the metal required. The following table of alloys may be taken as a fair standard.

	Copper	Zinc	Tin	Lead	Nickel	Antimony
Babbitt's metal	3.7	....	89	....	....	7.3
Brass, common	84.3	5.2	10.5	....	....	....
Brass, hard	79.3	6.4	14.3	....	....	....
Brass, locomotive bearings	90	1	9	....	....	....
Brass, rolled	74.3	22.3	3.4	....	....	....
Brass, very tenacious	88.9	2.8	8.3	....	....	....
Britannia metal	....	....	26	....	....	25
Bronze, red	87	13	....	....	....	....
Bronze, yellow	67.2	31.2	1.6	....	....	....
Bronze, gun metal, large	90	....	10	....	....	....
Bronze, gun metal, small	93	....	7	....	....	....
Bronze, gun metal, soft	95	....	5	....	....	....
Bronze, cymbals	80	....	20	....	....	....
Bronze, medals	93	....	7	....	....	....
Bronze, statuary	91.4	5.5	1.4	1.7	....	....
Church bells	80	5.6	10.1	4.3	....	....
Clocks, musical bells	87.5	....	12.5	....	....	....
Clock bells	72	....	26.5	....	....	1.5
German silver	33.3	33.4	....	....	33.3	2.6
German silver, fine	49.5	24	....	....	24	2.5
Gongs	81.6	....	18.4	....	....	....
House bells	77	....	23	....	....	....
Lathe bushes	80	....	20	....	....	....
Machinery bearings	87.5	....	12.5	....	....	....
Machinery bearings, hard	77.4	7	15.6	....	Bismuth	....
Metal that expands in cooling	....	....	....	75	8.3	16.7
Muntz metal, 10 oz. lead	60	40	....	....	....	....
White metal	7.4	7.4	28.4	....	....	56.8

SPEED OF DRILLS FOR STATIONARY DRILL PRESSES

The following table shows the revolutions per minute for Drills from 1/16 inch to 2 inches diameter, as usually applied. Oil drills can usually be run 25 per cent. faster.

Diameter of Drills, Inches	Speed for Wrought Iron and Steel	Speed for Cast Iron	Speed for Brass
1/16	1712	2383	3544
1/8	855	1191	1772
3/16	571	794	1181
1/4	397	565	855
5/16	318	452	684
3/8	265	377	570
7/16	227	323	489
1/2	183	267	412
9/16	163	238	367
5/8	147	214	330
11/16	133	194	300
3/4	112	168	265
13/16	103	155	244
7/8	96	144	227
15/16	89	134	212
1	76	115	191
1 1/16	72	108	180
1 1/8	68	102	170
1 3/16	64	97	161
1 1/4	58	89	150
1 5/16	55	84	143
1 3/8	53	81	136
1 7/16	50	77	130
1 1/2	46	74	122
1 9/16	44	71	117
1 5/8	40	66	113
1 11/16	38	63	109
1 3/4	37	61	105
1 13/16	36	59	101
1 7/8	33	55	98
1 15/16	32	53	95
2	31	51	92

These speeds should seldom be exceeded. Feed per revolution for 1/4 inch Drill, .005 inch; for 1/2-inch Drill, .007 inch; for 3/4-inch Drill, .010 inch.

For Portable drilling judgment must be used as to speed.

SOLDERS

Variety	Zinc	Copper	Silver	Tin	Lead	Bismuth	Fusing Point
Spelter, hardest	1	2	....	....	....	....	700°
Spelter, hard	2	3	....	....	....	....	....
Spelter, soft	1	1	....	....	....	....	550°
Spelter, fine	2	2	1/4	....	....	....	....
Plumbers, coarse	....	....	....	1	2	....	480°
Plumbers, ordinary	....	....	....	1	2	....	440°
Plumbers, fine	....	....	....	2	3	....	400°
Tinners	....	....	....	1	1	....	370°
For Tin Pipe	....	....	....	3	2	....	330°
For Tin Pipe	....	....	....	4	4	1	....

SOLDERING FLUXES

Flux	Used With	Metals to be Joined
Resin	Copper bit or blowpipe	Lead, tin, copper, brass, and tinned metals
Tallow, unsalted	Wiping process. Copper bit or blowpipe	Lead, tin or tinned metal
Sal Ammoniac	....	Copper, brass, and iron
Muriatic Acid	Copper bit or blowpipe and copper bit	Dirty zinc, clean zinc, copper, brass, tin, and tinned metals
Chloride of Zinc	Copper bit or blowpipe	Lead and tin tubes
Resin and Sweet Oil	....	Iron, steel, copper, and brass
Borax	Blowpipe	Brass

MELTING POINTS OF METALS, IN FAHRENHEIT

	Degrees
Alloy, 3 Lead, 2 Tin, 5 Bismuth	200
Alloy, 1 Tin, 1 Lead	370–460
Aluminum	1,160
Aluminum Bronze	1,700
Antimony	950
Bismuth	510
Brass	1,870
Bronze	1,690
Copper	2,000
Gold	2,020
Iron, Cast (white)	2,075
Iron, Cast (gray)	2,264
Iron, Wrought	3,000–3,500
Lead	610
Magnesium	1,200
Mercury	39
Platinum	3,500
Steel	2,370–2,550
Silver	1,860
Tin	445
Zinc	700

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TABLE OF MARKET SIZES OF SHEET STEEL—COMMON STEEL PLATE

No. Size.	No. Size.	No. Size.	No. Size.	No. Size.	No. Size.
10 x 24 x 96	12 x 24 x 96	14 x 26 x 120	16 x 36 x 120	20 x 42 x 96	26 x 24 x 96
x 24 x 120	x 24 x 120	x 28 x 96	x 36 x 144	x 42 x 120	x 24 x 101
x 26 x 96	x 26 x 96	x 28 x 120	x 42 x 96	x 48 x 96	x 24 x 120
x 26 x 108	x 26 x 120	x 30 x 96	x 42 x 120	x 48 x 120	x 26 x 96
x 26 x 120	x 28 x 96	x 30 x 108	x 42 x 144		x 26 x 120
x 28 x 96	x 28 x 120	x 30 x 120	x 48 x 96		x 28 x 72
x 28 x 120	x 30 x 96	x 36 x 77	x 48 x 120	22 x 24 x 96	x 28 x 84
x 30 x 96	x 30 x 120	x 36 x 96	x 48 x 138	x 24 x 101	x 28 x 96
x 30 x 108	x 36 x 96	x 36 x 120	x 48 x 144	x 24 x 120	x 28 x 108
x 30 x 120	x 36 x 108	x 36 x 144		x 26 x 96	x 28 x 120
x 36 x 96	x 36 x 120	x 42 x 96		x 26 x 120	x 30 x 96
x 36 x 108	x 36 x 144	x 42 x 120	18 x 24 x 96	x 28 x 72	x 30 x 120
x 36 x 120	x 42 x 96	x 48 x 77	x 24 x 120	x 28 x 84	x 36 x 96
x 36 x 144	x 42 x 120	x 48 x 96	x 26 x 96	x 28 x 96	x 36 x 120
x 42 x 96	x 48 x 77	x 48 x 108	x 26 x 120	x 28 x 108	x 42 x 96
x 42 x 120	x 48 x 96	x 48 x 120	x 28 x 96	x 28 x 120	x 42 x 120
x 48 x 77	x 48 x 108	x 48 x 138	x 28 x 120	x 30 x 96	
x 48 x 96	x 48 x 120	x 48 x 144	x 30 x 96	x 30 x 120	
x 48 x 108	x 48 x 138	x 48 x 156	x 30 x 120	x 36 x 96	27 x 24 x 96
x 48 x 120	x 48 x 144	x 54 x 77	x 36 x 96	x 36 x 120	x 24 x 101
x 48 x 138	x 48 x 156	x 54 x 96	x 36 x 120	x 42 x 96	x 28 x 96
x 48 x 144	x 54 x 77	x 54 x 120	x 42 x 96	x 42 x 120	x 28 x 101
x 48 x 156	x 54 x 96	x 54 x 138	x 42 x 120		x 28 x 120
x 54 x 77	x 54 x 120	x 54 x 144	x 48 x 96		x 30 x 96
x 54 x 96	x 54 x 138	x 54 x 156	x 48 x 120	24 x 24 x 96	
x 54 x 120	x 54 x 144			x 24 x 101	
x 54 x 138	x 54 x 156			x 24 x 120	28 x 24 x 96
x 54 x 144	x 60 x 77	16 x 24 x 96	20 x 24 x 96	x 26 x 96	x 24 x 101
x 54 x 156	x 60 x 96	x 24 x 108	x 24 x 120	x 26 x 120	x 26 x 96
x 60 x 77	x 60 x 120	x 24 x 120	x 26 x 96	x 28 x 72	x 28 x 72
x 60 x 96	x 60 x 138	x 26 x 96	x 26 x 120	x 28 x 84	x 28 x 84
x 60 x 120	x 60 x 144	x 26 x 108	x 28 x 72	x 28 x 96	x 28 x 96
x 60 x 138	x 60 x 156	x 26 x 120	x 28 x 84	x 28 x 108	x 28 x 108
x 60 x 144		x 28 x 96	x 28 x 96	x 28 x 120	x 28 x 120
x 60 x 156		x 28 x 120	x 28 x 108	x 30 x 96	x 30 x 96
x 72 x 96	14 x 24 x 96	x 30 x 96	x 28 x 120	x 30 x 120	
x 72 x 120	x 24 x 108	x 30 x 108	x 30 x 96	x 36 x 96	
x 72 x 138	x 24 x 120	x 30 x 120	x 30 x 120	x 36 x 120	30 x 24 x 96
x 72 x 144	x 26 x 96	x 36 x 77	x 36 x 96	x 42 x 96	x 30 x 96
x 72 x 156	x 26 x 108	x 36 x 96	x 36 x 120	x 42 x 120	

TABLE OF MARKET SIZES OF SHEET STEEL—COMMON STEEL PLATE

No. Size.	No. Size.	No. Size.	No. Size.	No. Size.
8 x 28 x 96	3-16 x 46 x 138	1-4 x 42 x 120	5-16 x 30 x 120	3-8 x 30 x 120
x 30 x 96	x 48 x 120	x 42 x 138	x 30 x 138	x 36 x 120
x 30 x 120	x 48 x 138	x 44 x 98	x 36 x 120	x 36 x 138
x 36 x 96	x 48 x 144	x 44 x 120	x 36 x 138	x 40 x 120
x 36 x 120	x 48 x 156	x 44 x 138	x 36 x 144	x 40 x 138
x 36 x 138	x 48 x 175	x 44 x 144	x 36 x 156	x 44 x 120
x 40 x 96	x 48 x 194	x 44 x 156	x 38 x 120	x 44 x 138
x 40 x 120	x 49 x 98	x 46 x 120	x 38 x 138	x 48 x 120
x 40 x 138	x 50 x 120	x 46 x 138	x 40 x 120	x 48 x 138
x 42 x 96	x 50 x 138	x 48 x 98	x 40 x 138	x 48 x 144
x 42 x 120	x 50 x 144	x 48 x 120	x 42 x 120	x 48 x 156
x 48 x 96	x 50 x 156	x 48 x 138	x 42 x 138	x 48 x 194
x 48 x 120	x 54 x 98	x 48 x 144	x 44 x 120	x 50 x 120
x 48 x 138	x 54 x 120	x 48 x 156	x 44 x 138	x 50 x 138
x 48 x 144	x 54 x 138	x 48 x 194	x 44 x 144	x 54 x 120
x 48 x 156	x 54 x 144	x 50 x 120	x 44 x 156	x 54 x 138
x 54 x 96	x 54 x 156	x 50 x 138	x 46 x 120	x 57 x 118
x 54 x 120	x 60 x 98	x 50 x 144	x 46 x 138	x 60 x 120
x 54 x 138	x 60 x 120	x 50 x 156	x 48 x 120	x 60 x 138
x 54 x 144	x 60 x 138	x 54 x 98	x 48 x 138	x 60 x 144
x 60 x 98	x 60 x 144	x 54 x 120	x 48 x 144	x 60 x 156
x 60 x 120	x 60 x 156	x 54 x 138	x 48 x 156	x 60 x 194
x 60 x 138	x 60 x 175	x 54 x 144	x 48 x 194	x 65 x 118
x 60 x 144	x 60 x 194	x 54 x 156	x 50 x 120	x 72½ x 118
x 60 x 156	x 72 x 98	x 54 x 194	x 50 x 138	x 72½ x 138
	x 72 x 120	x 60 x 98	x 50 x 144	x 72½ x 144
3-16 x 24 x 120	x 72 x 138	x 60 x 120	x 50 x 156	x 72½ x 156
x 26 x 120	x 72 x 144	x 60 x 138	x 54 x 120	x 72½ x 194
x 26 x 138	x 72 x 156	x 60 x 144	x 60 x 98	x 72½ x 212½
x 28 x 120	x 72 x 175	x 60 x 156	x 60 x 120	x 72½ x 232½
x 30 x 98	x 72 x 194	x 60 x 175	x 60 x 138	x 96 x 118
x 30 x 120		x 60 x 194	x 60 x 144	x 96 x 212½
x 30 x 138		x 72 x 98	x 60 x 156	x 96 x 232½
x 36 x 98	1-4 x 24 x 120	x 72 x 120	x 60 x 175	
x 36 x 120	x 26 x 120	x 72 x 138	x 60 x 194	1-2 x 36 x 120
x 36 x 138	x 26 x 138	x 72 x 144	x 72 x 120	x 40 x 120
x 36 x 144	x 30 x 98	x 72 x 156	x 72 x 138	x 48 x 120
x 36 x 156	x 30 x 120	x 72 x 175	x 72 x 144	x 60 x 120
x 38 x 120	x 30 x 138	x 72 x 194	x 72 x 156	x 65 x 118
x 38 x 138	x 36 x 98	x 84 x 98	x 72 x 175	x 72½ x 118
x 40 x 98	x 36 x 120	x 84 x 120	x 72 x 194	x 72½ x 138
x 40 x 120	x 36 x 138	x 84 x 138	x 84 x 120	x 72½ x 144
x 40 x 138	x 36 x 144	x 84 x 144	x 84 x 138	x 72½ x 156
x 40 x 144	x 36 x 156	x 84 x 156	x 84 x 144	x 72½ x 232
x 40 x 156	x 38 x 98	x 84 x 175	x 84 x 156	x 96 x 118
x 42 x 120	x 38 x 120	x 84 x 194	x 84 x 175	x 96 x 232
x 42 x 138	x 38 x 138	x 96 x 98	x 84 x 194	
x 44 x 98	x 38 x 144	x 96 x 120	x 96 x 120	
x 44 x 120	x 40 x 98	x 96 x 138	x 96 x 138	
x 44 x 138	x 40 x 120	x 96 x 144	x 96 x 144	
x 44 x 144	x 40 x 138	x 96 x 156	x 96 x 156	
x 44 x 156	x 40 x 144	x 96 x 175	x 96 x 175	
x 46 x 120	x 40 x 156	x 96 x 194	x 96 x 194	

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Shop Data

WEIGHTS AND DIMENSIONS OF LEAD PIPE

Western Standard	Caliber, Inches	Outside Diameter, Inches	Weight per Foot, Pounds	Average Feet in Coil
A	⅜	0.49	0.50	140
XL		0.52	0.56	124
L		0.57	0.75	94
M		0.61	1.00	70
S		0.73	1.50	93
XS		0.75	2.00	70
XXS		0.79	2.50	56
A	½	0.64	0.63	280
XL		0.66	0.75	230
L		0.70	1.00	175
M		0.75	1.25	140
S		0.85	1.75	100
AA		0.89	2.00	87
XS		0.94	2.50	70
XXS		1.01	3.00	58
4 lb.		1.12	4.00	43
A	⅝	0.77	0.75	230
XL		0.84	1.25	138
L		0.92	1.75	98
M		0.95	2.00	86
S		1.02	2.50	69
AA		1.05	2.75	62
XS		1.08	3.00	57
XXS		1.15	3.50	49
4 lb.		1.19	4.00	43
A	¾	0.91	1.00	171
XL		0.97	1.50	114
L		1.04	2.00	85
M		1.07	2.25	76
S		1.16	3.00	57
XS		1.23	3.50	49
XXS		1.26	4.00	43
5 lb.		1.35	5.00	34
A	1	1.17	1.50	112
XL		1.23	2.00	84
L		1.27	2.50	67
M		1.35	3.25	52
S		1.43	4.00	42
XS		1.49	4.75	35
XXS		1.56	5.50	58
7 lb.		1.66	7.00	45
A	1¼	1.43	2.00	84
XL		1.49	2.50	67
L		1.53	3.00	56
M		1.58	3.75	85
S		1.66	4.75	67
XS		1.77	6.00	53
XXS		1.83	6.75	47
9 lb.		1.89	9.00	35
A	1½	1.74	3.00	56
XL		1.77	3.50	48
L		1.82	4.00	42
M		1.89	5.00	64
S		1.93	6.00	53
XS		2.05	7.50	42
XXS		2.13	9.00	35
11 lb.		2.19	11.00	29
A	2	2.19	3.00	12′ length
XL		2.23	4.00	12′ length
L		2.28	5.00	12′ length
M		2.41	7.00	43′ coil
S		2.46	8.00	38′ coil
XS		2.52	9.00	34′ coil
XXS		2.61	10.50	29′ coil
15 lb.		2.83	15.00	20′ coil

Lead pipe of all sizes furnished on reels any length required.

American Lead Co.

UNITED STATES STANDARD GAUGE FOR SHEET AND PLATE STEEL

Number of Gauge	Thickness in Fractions of an Inch	Thickness in Decimal Parts of an Inch	Weight per Square Foot in Pounds
0000000	1-2	.5	20.4
000000	15-32	.46875	19.125
00000	7-16	.4375	17.85
0000	13-32	.40625	16.575
000	3-8	.375	15.30
00	11-32	.34375	14.035
0	5-16	.3125	12.75
1	9-32	.28125	11.475
2	17-64	.265625	10.84
3	1-4	.25	10.2
4	15-64	.234375	9.563
5	7-32	.21875	8.925
6	13-64	.203125	8.287
7	3-16	.1875	7.65
8	11-64	.171875	7.012
9	5-32	.15625	6.375
10	9-64	.140625	5.737
11	1-8	.125	5.1
12	7-64	.109375	4.462
13	3-32	.09375	3.825
14	5-64	.078125	3.187
15	9-128	.0703125	2.868
16	1-16	.0625	2.55
17	9-160	.05625	2.395
18	1-20	.05	2.04
19	7-160	.04375	1.785
20	3-80	.0375	1.53
21	11-320	.034375	1.402
22	1-32	.03125	1.275
23	9-320	.028125	1.147
24	1-40	.025	1.02
25	7-320	.021875	.8925
26	3-160	.01875	.765
27	11-640	.0171875	.7012
28	1-64	.015625	.6375
29	9-640	.0140625	.5737
30	1-80	.0125	.51
31	7-640	.0109375	.4462
32	13-1280	.01015625	.4144
33	3-320	.009375	.3825
34	11-1280	.00859375	.3506
35	5-640	.0078125	.3187
36	9-1280	.00703125	.2868
37	17-2560	.006640625	.2709
38	1-160	.00625	.255

TABLE FOR PUNCHING PLATES

This table gives the greatest thickness of steel in which it is advisable to punch round or square holes of given diameter or sizes. Spacing, strain upon the plate, wear of dies and other considerations determine what is advisable. While the table is offered as a convenient guide in ordering, thinner plates will generally answer every requirement, and cost less.

DIAMETER OF HOLE			BIRMINGHAM GAUGE		
Millimeters	Inches	Decimal of an Inch	No.	Thickness in Inches	Weight per Sq. Ft. Pounds
¾	.....	.02952	26	.018	.731
1	.....	.03937	24	.022	.894
....	3/64	.04687	22	.028	1.138
1¼	.....	.04921	20	.035	1.423
1½	.....	.05906	18	.049	1.992
....	1/16	.06250	18	.049	1.992
....	5/64	.07812	16	.065	2.642
2	.....	.07874	16	.065	2.642
2¼	.....	.08858	16	.065	2.642
....	3/32	.09375	16	.065	2.642
2½	.....	.09843	16	.065	2.642
3	.....	.11811	14	.083	3.374
....	⅛	.125	14	.083	3.374
3¼	.....	.12795	14	.083	3.374
3½	.....	.1378	12	.109	4.431
....	9/64	.14062	12	.109	4.431
4	.....	.15748	12	.109	4.431
4½	.....	.17717	10	.134	5.448
....	3/16	.18750	10	.134	5.448
5	.....	.19685	10	.134	5.448
5½	.....	.21654	10	.134	5.448
6	.....	.23622	10	.134	5.448
....	¼	.250	8	.165	6.708
6½	.....	.25591	8	.165	6.708
7	.....	.27559	3/16	.187	7.622
....	9/32	.28125	3/16	.187	7.622
....	5/16	.3125	3/16	.187	7.622
8	.....	.31496	3/16	.187	7.622
9	.....	.35433	3/16	.187	7.622
....	⅜	.375	3/16	.187	7.622
10	.....	.3937	¼	.250	10.163
11	.....	.43307	¼	.250	10.163
....	7/16	.4375	¼	.250	10.163
12	.....	.47244	¼	.250	10.163
....	½	.500	¼	.250	10.163
13	.....	.51181	¼	.250	10.163
14	.....	.55518	¼	.250	10.163
15	.....	.59055	¼	.250	10.163
....	19/32	.59375	¼	.250	10.163
....	⅝	.625	¼	.250	10.163
19	.....	.74803	¼	.250	10.163
....	¾	.750	¼	.250	10.163
22	.....	.86614	¼	.250	10.163
....	⅞	.875	¼	.250	10.163
25	.....	.98425	¼	.250	10.163
	1	......	5/16	.312	12.703

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CHICAGO PNEUMATIC TOOL CO.

Chicago Pneumatic Bldg.
6 East 44th Street, NEW YORK

SALES AND SERVICE BRANCHES ALL OVER THE WORLD

Products

Air Compressors — Gas, Oil, Gasoline, Steam, Belt and Motor Driven; Vacuum Pumps and Gas Compressors; Receivers and Aftercoolers; Semi-Diesel Oil Engines; Gas and Steam Engines; Little Giant Air Hoists for Mine and Shop; Air and Electric Rock and Coal Drills; Boyer Pneumatic Hammers for Riveting, Chipping, etc.; Little Giant Electric Tools; Air Hose; Accessories.

Boyer Riveting Hammers

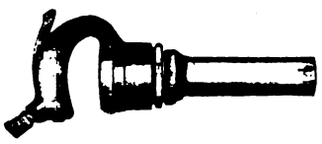
The world's standard wherever rivets are driven. Divided into three distinct members—cylinder, handle and valve. Handles are interchangeable on all sizes of like type. The Boyer valve is so designed that the piston passes through it—thus the overall hammer length is shortened, and speedy, powerful action is obtained. Easily inspected and repaired.

Sectional View, Boyer Long Stroke Riveting Hammer. All moving parts function in the same plane, in direct alignment with the operator's arm permitting more and better work with less fatigue.

Made in a variety of sizes to provide the right tool for any riveting hammer operation. The smaller models (as type H) are particularly useful for light work, such as mine car bodies, bins, sheet metal tanks, etc. Save time over hand methods and at the same time insure better and more uniform rivets. Ask for Bulletin 810.

Boyer and Keller Calking and Chipping Hammers

Made in a complete range of sizes. Useful in every shop having compressed air, for chipping gray iron and steel castings and alloy steel ingots, calking seams, trimming flush head rivets, beading flues, etc. These are only a few of the jobs which can be performed at greater speed with less effort by the use of these tools. Ask for Bulletin 810.



Boyer "BK" Type Chipping and Calking Hammer.

Keller Pneumatic Rammers

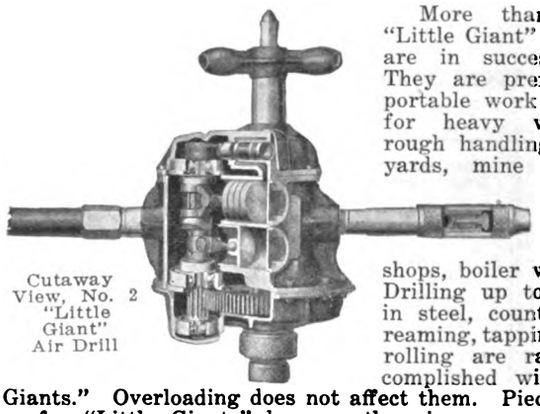
Speed up and improve the quality of foundry work. Moulds may be rammed much harder with less manual effort. Increased uniformity obtained greatly reduces number of defective castings. Also much used in ramming concrete and for tamping ties. Ask for Bulletin 640.

"Little Giant" Air Drills

For countless drilling, reaming, tapping, nut and bolt tightening, screw setting, flue-rolling and countersinking operations, no portable drilling machine yet devised has excelled the flexibility of "Little Giant" portable air drills. These sturdily built, easily handled tools are built in a wide variety of sizes and types to completely meet any or all requirements.

"Little Giant" Air Drills have several distinctive features of design which contribute to their reputation for unusual power, low upkeep cost and economy in air consumption.

These features are readily seen in accompanying illustration; a 3-point ball bearing crank shaft—low friction, consequent economy of air consumption and gears held rigidly in line; balanced piston valves with large area and short ports—give fast drilling through quick air admission and exhaust; thorough lubrication—oil put in at one place reaches all bearing surfaces; exhaust air does not pass through the working parts and dry the oil, and all working parts enclosed in dust-proof three-unit housing with each unit separately renewable when worn.



Cutaway View, No. 2 "Little Giant" Air Drill

More than 125,000 "Little Giant" Air Drills are in successful use. They are preferred for portable work in shops; for heavy work and rough handling in shipyards, mine and mill shops, boiler works, etc. Drilling up to 3 inches in steel, countersinking, reaming, tapping and flue rolling are rapidly accomplished with "Little Giants." Overloading does not affect them. Piece-workers prefer "Little Giants" because they increase output and earnings.

Made in reversible and non-reversible models, with different drilling speeds ranging from 50 to 2200 r.p.m.; with square or Morse taper shank, and with feed-screw, grip handle or breast plate equipment. For full information on the complete line ask for Bulletin 598.

No. 10-F "Little Giant" Midget Type Air Drill.

"Little Giant" corner or close quarters drills can be used within 1½ in. of an end wall or corner. They do the work of a ratchet type drill in a fraction of the time. Ask for Bulletin 598.

Wood Boring Machines

A complete line of pneumatic wood boring machines is available in capacities up to 4 inches. Handle standard wood-boring bits. Also used for screwing in and tightening nuts and bolts. An especially valuable tool around mills. Bulletin 598.

Wood-Boring tasks are easily met with "Little Giant" Wood Borers.

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TABLE IV-a. "LITTLE GIANT" AIR DRILLS

¶†§ Size No.	Speed Light, r.p.m.	‖¶Air Used per min cu. ft.	*Socket	°Capacity Drill, in.	Ream	Tap	Flue Roll	Net Weight, lb.	Code
10-F	2200	11	00	¼	...	...	...	8	ABOBELLA
10-S	1000	7	0	⅜	...	...	...	8¾	ABOBESTIC
3-S (1)	1800	15	0	½	...	...	...	11½	ABOCADLIC
3-RS (1)	1200	15	0	½	...	...	...	14½	ABORINFELT
3-A (2)	800	15	1	9/16	...	...	...	12	ABOMASTER
4 (2)	800	20	2	⅞	½	⅝	...	22	ABOCAFE
4R (2)	360	18	2	⅞	½	⅝	¾	24	ABOBRAND
4T	370	18	2	...	½	⅝	¾	24	ABOBREATH
4C (2)	240	20	3	1¼	1¼	1¼	...	28	ABOBROOM
4RC (2)	125	18	3	1¼	1¼	1¼	2	30	ABOBRITISH
4TC	130	18	3	...	1¼	1¼	2	30	ABOBRIDE
2 (2)	480	25	3	1¼	1	1	...	40	ABOCALLA
2R (2)	325	20	3	1¼	1	1	2	42	ABOCABRA
12	325	20	3	...	1	1	2	44	ABOCABLING
2C (2)	155	25	4	2	1½	1½	...	52	ABOCALYX
2RC (2)	120	20	4	2	1½	1½	2½	54	ABOCASTER
12C	120	20	4	...	1½	1½	2½	56	ABOCAXTON
1 (2)	400	35	4	2	2	2	...	58	ABOCENTRIC
1R (2)	230	30	4	2	2	2	2½	60	ABOCERVIX
11	230	30	4	...	2	2	2½	60	ABOCEVIER
15 (2)	260	35	4	2	2¼	2¼	...	65	ABOCEDILLA
15R (2)	180	30	4	2	2¼	2¼	3	68	ABOCEFFRON
15T	180	30	4	...	2¼	2¼	3	68	ABOCELERY
1C (2)	110	35	5	3	2½	2½	...	75	ABOCEREAL
1RC (2)	65	30	5	3	2½	2½	4	78	ABOCIMITAR
11C	58	30	5	...	2½	2½	4	78	ABOCIVIC
15C (2)	80	35	5	3			...	83	ABOCIBALD
15RC (2)	52	30	5	3	‡		4	97	ABOCIRCUM
15TC	50	30	5	...			4	97	ABOCIGRAND

*Nos. 00 and 0 indicate chuck sizes; other numbers indicate Morse taper sockets.

†Nos. in parentheses indicate the following regular equipment: (1) Breast plate and No. 0 chuck. (2) Feed screw. (3) Ratchet wrench for feed screw. (4) Grip handle and wood bit chuck. (5) Wood bit chuck.

‡Adapted for special extra heavy reaming and tapping.

§Letter "R" indicates reversible type drills; letter "C" indicates compound geared drills; letter "T" indicates drills fitted with grip handles and especially adapted for tapping, flue rolling or reaming.

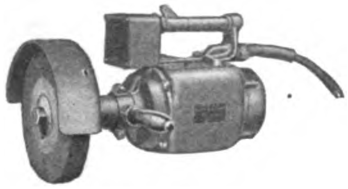
°Drilling capacities are for drilling in metal.

‖Nos. 10-F to 3-A inclusive, and No. 3 have ¼-in. hose connections; Nos. 4 to 91-R inclusive have ½-in. hose connections.

¶At 80-lb. pressure.

"Little Giant" Pneumatic Grinders

The advantage of portability possessed by all pneumatic tools is no doubt most fully realized in the pneumatic grinder. "Little Giant" grinders are adaptations of the smaller sizes of "Little Giant" air drills. The grinding wheel is mounted on an extension of the crankshaft. Made in four sizes. Ask for Bulletin 598.



No. 8-BP "Little Giant" D.C. Electric Portable Grinder.

"Little Giant" Electric Grinders

Same general construction as "Little Giant" electric drills, but fitted with arbors for carrying abrasive wheels. Built in portable, tool-post and precision-grinding types. Foundries, machine shops, mines, manufacturing plants can use these tools for many labor-conserving purposes. Ask for Bulletin E-61.

TABLE V. "LITTLE GIANT" ELECTRIC DRILLS— DRILLING CAPACITIES IN METAL

Size	*Universal for 110 and 220 Volt, in.	D.C. for 120 and and 240 Volt, in.	**A.C. for 2 Phase and 3 Phase, in.	D. C. for 600 Volt, in.
000	3/16	...	...	...
000x	¼	...	...	...
00-B	3/16	...	...	...
0-B	⅜	⅜	⅜	...
1B	½	½	½	½
1½-B	¾	¾	¾	⅝
2B	⅞	⅞	⅞	¾
3B	1¼	1¼	1¼	1
4B	...	2	2	1½

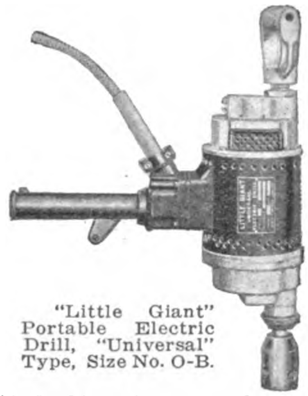
*For connection to ordinary lamp socket. D.C. or A.C. of. 60 cycles or less, single-phase, interchangeably.

**Furnished in side spindle style only. Standard windings are for 60 cycles, 120 or 240 volts. Nos. 2, 3 and 4 can be wound for 380 or 440 volts.

NOTE: In ordering specify Size No.; also whether D.C. or A.C. or "Universal" type is desired. (If A.C., specify phase.)

"Little Giant" Portable Electric Drills

Built with direct, alternating or "Universal" current motors in several sizes and types. Have ball bearings, stub tooth gears, ample ventilating and cooling systems, and high overload capacity without undue temperature rise. Controlled by patented non-arcing handle switch.



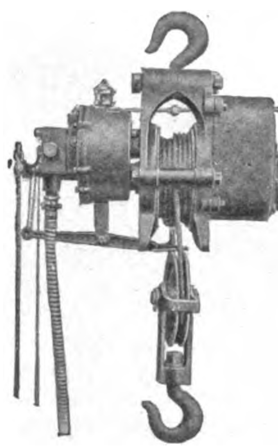
"Little Giant" Portable Electric Drill, "Universal" Type, Size No. O-B.

"Little Giant" electric drills are light in weight, easily portable. Taking the drill to the work saves carrying parts to drill presses, saves setting-up time, and expensive machine-tool operations. Universally used in machine shops, garages, and also in the largest manufacturing operations. Thousands are profitably used in the Ford plants, where scientific minimum cost production is most highly developed. Frequently a small investment in "Little Giants" will produce a material increase in output per day. D. C. type drills are described in Bulletin 581; A. C. types in Bulletin E-58; and "Universal" types in Bulletin 616.

These tools are built also in semi-portable type for drilling and reaming track joint holes. Such outfits, now in wide use by electric and steam railways, are 10 to 12 times faster and 90 per cent cheaper than old-time hand methods. Ask for Bulletin E-60.

"Little Giant" Air Motors, Winches and Geared Hoists

All "Little Giant" air winches and hoists are operated by a simple and reliable air motor. This motor has two double-acting oscillating cylinders. Oscillation of cylinders opens and closes the ports—no other valve gear is necessary. Great power is obtained through a high motor speed, 240 to 1100 r.p.m. Motor is reversible, easily controlled, has automatic lubrication and is of very rugged construction throughout.



Size No. 12 "Little Giant" Two-Strand Three-Ton Portable Geared Air Hoist. Showing limit stop and chain control.

Pneumatic Portable Geared Hoists — Made in capacities from 1 to 10 tons. Motor is controlled by chains from floor, or by remote control as desired. Safety is assured by an automatic air brake which holds the load at any desired point. A simple limit stop provides absolute protection against overhoisting. When desired, these hoists will be furnished with plain single track trolley; geared single or geared double track trolley. For full details ask for Bulletin 648.

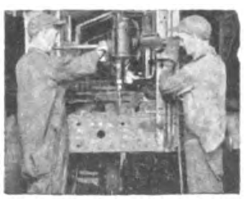
"LITTLE GIANT" PORTABLE GEARED AIR HOISTS

Size	Capacity (Tons)	Height of Lift, ft.	Lifting Speed (per min.) ft.	Min. Distance Between Hooks, in.	Air Consumption per ft. lift, cu. ft.	Net Weight, lb.	Code
10	1	9	28	39	3	355	ACCRESCENT
11	2	9	16	39	4	360	ACCRETION
12	3	11	10	45	8	465	ACCROACH
13	5	12	7	53½	15	820	ACCROIRE
14	10	12	4	61½	27	1080	ACCRUE

NOTE: When desired, "Little Giant" portable geared hoists can be supplied in any of the above sizes, except size 10, equipped with either a plain trolley, geared single track trolley, or a geared double track trolley. When ordering, always state size and weight of channels on which trolley must operate.

"Little Giant" Pneumatic Grinders Quickly Smooth Castings, Forgings, Etc.

Speeding Up Tank Riveting with a Boyer Long Holder-On.



"Little Giant" Electric Drills Work "Wherever There Is an Electric Socket."

Speeding Up Track Construction with "Little Giant" Electric Track Drills.

"Little Giant Trolley Mounted Air Hoist in Tank Shop Service.

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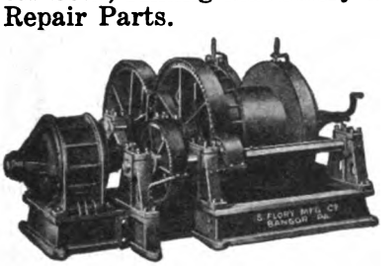
Pittsburgh Mining Machinery Company

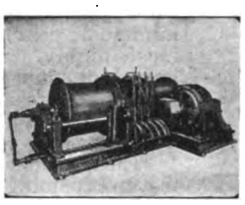
PITTSBURGH, PA.

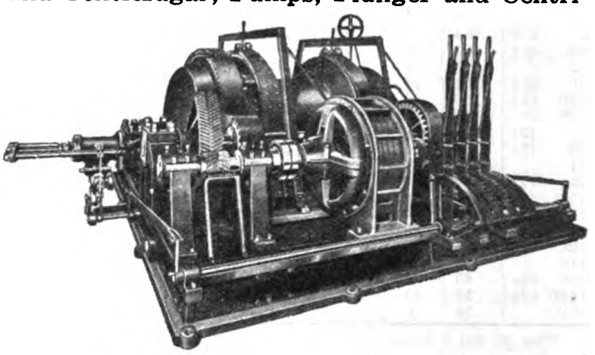
Works, Magnolia & Cantril Sts., N. S.

Products

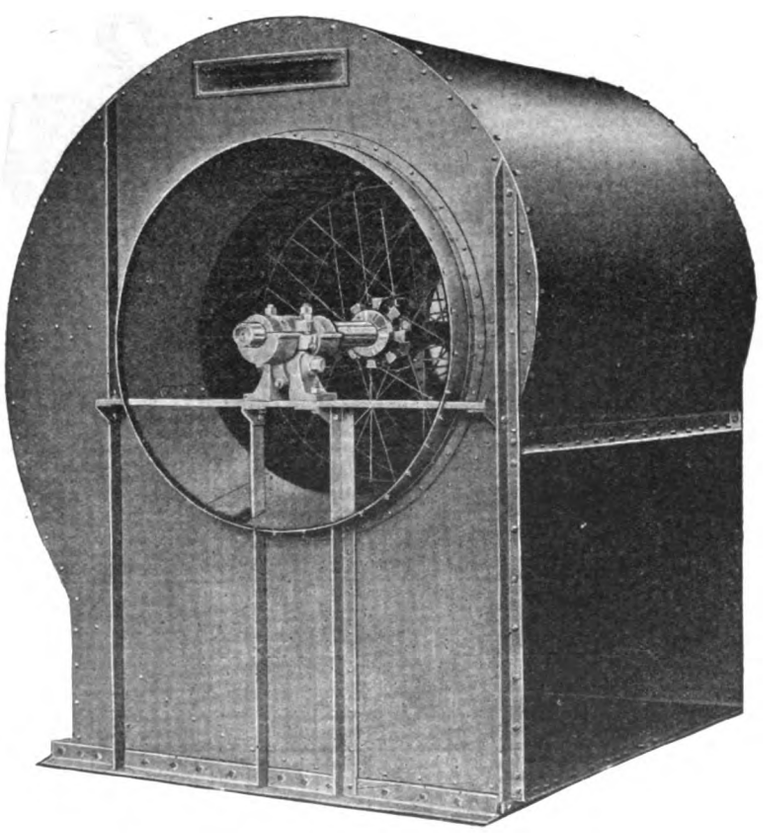
Hoists, Steam and Electric; Cages; Skip Cars and Buckets; Rotary Car Dumpers; Sheaves; Head Frames; Aerial Cableways; Power Hammers; Fans, Disc and Centrifugal; Pumps, Plunger and Centrifugal; Wire Rope; Engines, Steam and Internal Combustion; Motors; Motor Generator Sets, Engine Generator Sets; Mining Machinery and Equipment; Repairs and Repair Parts.





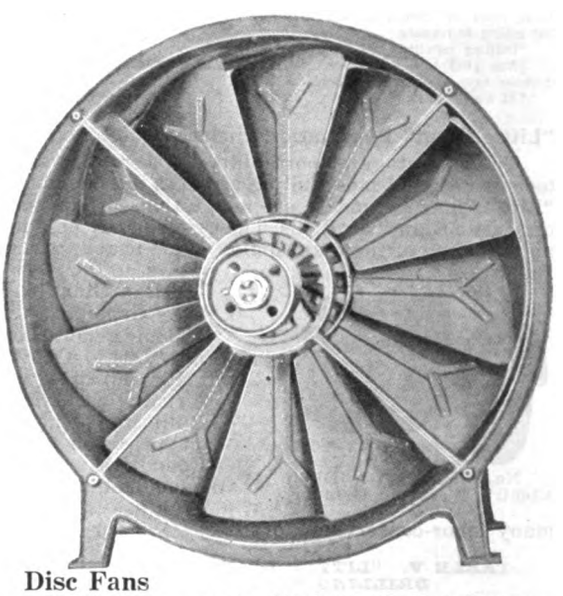


Hoists, Steam, Electric or Gasoline, any size for any duty. Built to any specifications. Cylindrical or Cylindro-conical Drums as desired. Single or double drum for tail rope, etc.



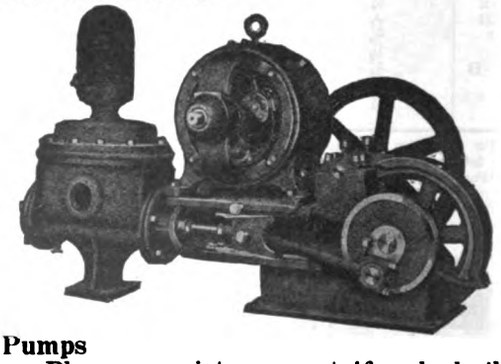
Centrifugal Fans

Blower, Exhaust or both at will of operator. Driven with any kind or type of power driver. Note spokes are of ¾" Round Steel bicycle type construction. Most accurate, strongest and highest efficiency guaranteed.



Disc Fans

Diameter up to 12 feet. Roller Bearing if desired. Standard have self-aligning bearing.



Pumps

Plunger, piston, centrifugal built especially for mine service with any type power as driver.

Our plant is modern and equipped for both mechanical and electrical work of Coal Cutter Parts and Mine Equipment

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HAUCK MANUFACTURING CO.

Tenth and Eleventh Sts. near Second Ave.
BROOKLYN, N. Y.

Kerosene Blow Torches—Oil Burners, Portable and for Furnaces—Thawing Outfits

Products

Torches of all sizes and for all heating purposes. Locomotive Tire Heaters, Thawing Outfits, Concrete Heaters. Forges—Rivet Heating, Drill Heating, Blacksmithing, Brazing, etc. Foundry Equipment. Furnaces for Melting Lead and Babbitt, all sizes. Preheaters in connection with Welding, Storage Battery Steamers, Locomotive Fire Kindlers, Furnace Burners.

Hauck Welded Steel Kerosene Hand Torches

Produce an intense reddish blue flame without smoke or soot. The solid cast bronze burner is constructed with straight oil passage ways. No coils. Easily cleaned. Recommended for straightening, bending, brazing, light blacksmithing, annealing, tempering, hardening. Write for Bulletin No. 112.

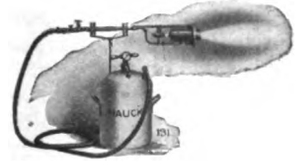
No.	Capacity	Oil Consumption	Lgth. Full Flame
10	1 qt.	1 qt.	8"
14	½ gal.	2 qts.	13"
15	1 gal.	2½ qts.	15"
16	1½ gal.	3 qts.	18"

Hauck High Pressure Furnace Burners

For Furnaces and Forges. Burns distillate, kerosene, fuel oil or crude oil in connection with compressed air or steam at pressures from 20 to 100 lbs. No smoke, soot or carbon. Oil may be fed by gravity pressure or suction. Made in 6 sizes. Write for Bulletin No. 119.

No.	Oil Consumption per Hour	Air Consumption Free Air (or Steam) per Minute
1-F	10–25 gal.	20 cu. ft.
2-F	6–10 gal.	15 cu. ft.
4-F	3–6 gal.	12 cu. ft.
5-F	1–3 gal.	8 cu. ft.
6-F	1½ gal.	5 cu. ft.
25-F	¾ gal.	2 cu. ft.

Hauck Hand Pump Vaporizing Type Equipment

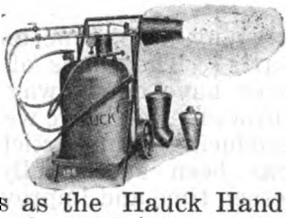


Must be preheated before starting. Recommended where compressed air is not available. Heavy brass pump in tank for generating pressure on the oil. Made in 5 sizes.

No.	Capacity of Tank Gallons	Length of Hose Feet	Oil Consumed per Hour Gallons	Lenght Full Flame Inches	Shipping Weight Pounds
11	3	6	½	18	50
7a	5	6	1	20	60
7	10	12	1½	22	80
8	12	12	2½	28	95
9	15	12	3	34	110

Unexcelled for locomotive and steel car repairs, preheating in connection with welding, brazing broken machine parts and castings, straightening axles, chassis, frames, shafting, buckled plates, girders, etc., bending pipe, rails, beams, etc., etc., Write for Bulletin No. 112.

Compressed Air Type Equipment



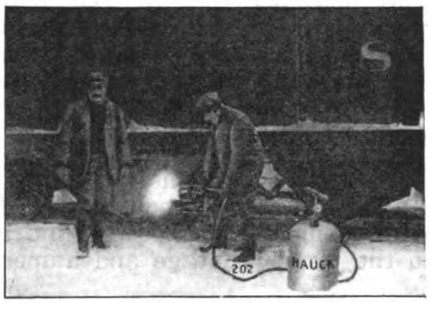
Burns crude oil, kerosene oil, fuel oil or distillate with compressed air at 20 to 100 lbs. pressure. Lights instantly without preheating. No carbonization. Made in 5 sizes.

Used for same purposes as the Hauck Hand Pump Type Equipment. Write for Bulletin No. 112.

No.	Cap. of Tank Gals.	One Length Oil & Air Hose Ft.	Oil Consumed per Hr. Gals.	Air Consumed Cu. Ft. Free Air per Minute	Shipping Weight Lbs.	Weight Burner Lbs.	Length Normal Flame Inches
5A	5	12 each	1	5	55	8	18
5	10	12 each	2	8	75	8	22
4	12	12 each	3	12	85	13	28
2	15	12 each	4	15	100	16	30
1	16	12 each	5	20	110	19	48

Hauck Thawing Outfits

Hauck kerosene thawers are used by many mines for thawing out hoppers on coal and ore cars, thawing out switches, frozen pipe lines, removing ice and snow from concrete shafts, etc. They give excellent service in severe weather and can be successfully handled by any inexperienced laborer. Write for Bulletin No. 116.



No.	Capacity of Steel Tank	Length of Hose	Oil Consumption per Hour	Net Weight Complete Outfit	Weight of Burner
11T	3 gal.	6 ft.	2 gal.	30 lbs.	6 lbs.
12T	5 gal.	6 ft.	2 gal.	40 lbs.	6 lbs.
7T	10 gal.	12 ft.	3 gal.	80 lbs.	8 lbs.
8T	12 gal.	12 ft.	3 gal.	95 lbs.	8 lbs.

Hauck Concrete Heaters

For heating concrete in the mixer. Makes placing of concrete in winter just as safe as in the summer.

Made in various sizes; two types—Hand Pump and Compressed Air or Steam. Write for Bulletin No. 130.

Hauck Tire Heaters

Compressed air and hand pump types, for removing locomotive tires up to 40". The wheel from which the tire is to be taken is jacked up and a sectional shield placed around it; will remove tires in less than 15 minutes. Burners can be quickly and easily attached and used for steel car repairs, preheating, brazing, melting babbitt, expanding, straightening, bending, thawing, etc., etc. Write for Bulletin No. 110.

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Allan Manufacturing & Welding Corporation

BUFFALO, NEW YORK

Manufacturers of

Allan, Poly Phase, Electric Arc Welders

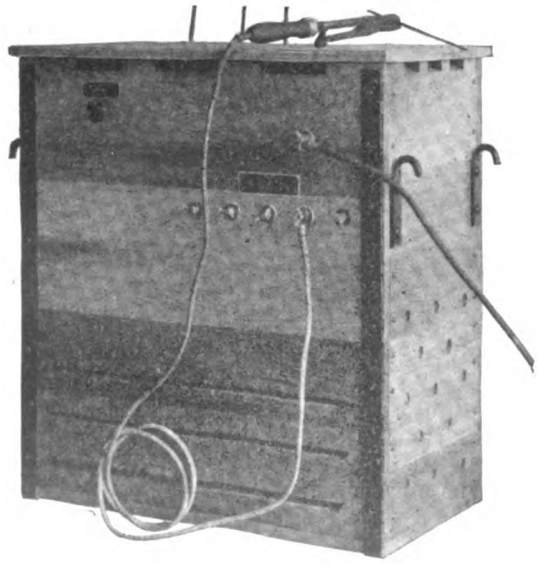
And Dealers in Electric Arc Welding Accessories

Why lose time and money waiting for new parts? Thousands of manufacturers the country over have done away with profit-eating delays through electric arc welding. In hundreds of plants, producing many articles, the arc welding process has been successfully applied to reduce costs, lessen time and improve quality.

All industrial plants should, and can, be entirely independent of the usual causes of delay in production. The intense heat of the electric arc, under which such metals as iron, steel, malleable iron, cast iron, wrought iron and cast steel in any form are easily handled, has solved the difficulty of uninterrupted output in up-to-the-minute industry. Breaks, cracks and worn surfaces, such as keep machinery idle for days and weeks, can be remade as good as new on the spot, and in a short space of time, by applying the electric arc to reclamation work in your plant. In every plant or operation of any consequence, there is room for the adoption of electric arc welding, and its value can only be determined by the use made of it.

Allan Poly Phase Arc Welders

Are specially constructed transformers which draw their current requirements from a polyphase alternating current power line and transform it to the proper voltage and amperage required for



Allan Poly Phase Arc Welders

successful arc welding. They are constructed to suit any alternating current primary power supply as to voltage and frequency.

Having no moving parts of any description, their life, with proper care, is permanent; they do not require the attention of a mechanic, no grease or oil for lubricating, no water, fan, or oil for cooling; no belts or pulleys for transmitting power from one unit to another, and eliminate all chance of fire or explosion. They have the approval of the Underwriters' Laboratories as to fire risk.

Applications of the Allan Arc Welder

Welding with the Allan Arc Welder can be used inside of boilers, tanks, fire-boxes and other difficult locations. Seams over the head of the operator can be welded with no real difficulty. Gear teeth can be built up, cracked cylinders, housings, gears, and in fact almost any piece of broken machinery, no matter how large or small, may be repaired at a fraction of the cost to replace it with new machinery.

The illustration below shows the application of arc welding as applied to a large gear.

8-Foot Cast Iron Gear Wheel, Broken in Two, Welded Without Preheating

You Require An Allan Welder Because:

1. It will make good, reliable welds.
2. First cost less.
3. Low comparative cost of installation.
4. Low power consumption.
5. It economizes time, space and money.
6. It is a practical, simple, economical, efficient and compact welder.
7. It is a permanent welder.
8. It is a portable welder.
9. It will meet your every requirement, as far as an electric welder can.

Our engineers are at your service. We are prepared to demonstrate the efficiency of our welders on your actual requirements.

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THE IMPERIAL BRASS MFG. CO.

508 South Racine Avenue, CHICAGO, ILL.

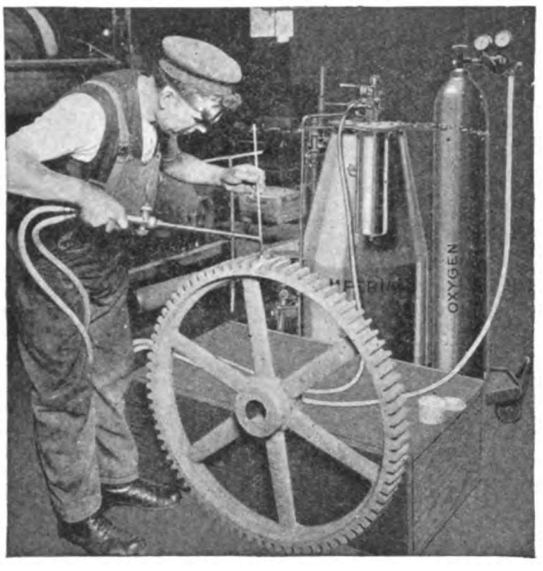
Manufacturers of

Oxy-Acetylene Welding & Cutting Equipment

Imperial Welding and Cutting Equipment in your repair shops means more coal at your tipples.

It eliminates those long delays due to breakage of coal cutters, haulage and power plant equipment by making quick, permanent repairs to all broken metal parts right on the spot, instead of waiting for new parts to be shipped.

If your mine is already using Welding Equipment of any make, the Imperial Automatic Acetylene Generator will not only save you from 2 to 5 cents per cubic foot of acetylene gas, but will end forever all delays and troubles in obtaining acetylene compressed in cylinders—to say nothing of the cylinder rental charge which is a permanent expenditure.



Repairing Broken Teeth in Gear with Imperial Welding Equipment. (Note Imperial Acetylene Generator in Rear.)

The Imperial Acetylene Generator possesses many marked advantages over other makes. The most important of these being the absence of weights, clock-work and complicated mechanism. In the Imperial Generator, the carbide feed is simple, sure and dependable, and is automatically controlled by the gas consumed by the torch—the generating of the gas automatically stops when the torch is extinguished and automatically starts generating when the torch is relighted, thus automatically maintaining a constant, even gas pressure.

Interlocking safety levers make the Imperial Generator absolutely foolproof, and compel the users to follow the proper sequence of the operations necessary to start or shut off the generator. A dependable safety blow-off makes it impossible to obtain more than 15 lbs. pressure.

Imperial Equipment is thoroughly practical, economical and safe. It is furnished in four outfits, as listed in opposite column, to meet the various requirements of service.

No other torch has a mixing principle like the IMPERIAL—scientific, practical, years ahead. IMPERIAL TORCHES are approved by the Underwriters' Laboratories of the National Board of Fire Underwriters. No other regulator so accurately and uniformly controls delivery of gases—none has its automatic safety features.

Imperial Welding and Cutting Outfits

No. 1 Imperial Welding Outfit

For all general welding work, from thin sheet metal to heaviest castings.

Consists of Type B Imperial Welding Torch with 10 welding tips, extension, carbon burning torch, regulators, 4 gauges, hose, connections, goggles, handbook, carrying case, complete supply of welding materials, ready for service. $75.00.

No. 5 Imperial Duplex Welding and Cutting Outfit

Best all purpose apparatus obtainable at any price. Fully adequate to handle all welding and cutting for which the process is adapted.

Consists of a complete No. 1 Imperial Welding Outfit, as described above, and also includes a Type E Imperial Cutting Torch with 2 housings and 4 tips and an extra pair of goggles and 25-ft. lengths of hose. Each, $120.00.

Imperial Acetylene Generators

15 lb. Imperial Acetylene Generator, 15 lbs. carbide capacity, 15 gallons water capacity produces 15 cubic feet of gas per hour or 75 cubic feet per charge at a cost of 75 to 90 cents. Complete with truck, $175.00. (Deduct $20.00 if truck is not wanted.)

25 lb. Imperial Acetylene Generator, 25 lbs. carbide capacity, 25 gallons water capacity produces 25 cubic feet of gas per hour or 125 cubic feet per charge at a cost of $1.25 to $1.50. Complete with truck, $200.00. (Deduct $20.00 if truck is not wanted.)

50 lb. Imperial Acetylene Generator, 50 lbs. carbide capacity, 50 gallons water capacity produces 50 cubic feet of gas per hour or 250 cubic feet per charge at a cost of $2.50 to $3.00. Complete without truck, $275.00.

100 lb. Imperial Acetylene Generator, 100 lbs. carbide capacity, 100 gallons water capacity produces 100 cubic feet of gas per hour or 500 cubic feet per charge at a cost of $5.00 to $6.00. Complete without truck, $425.00.

CATALOG ON REQUEST

Note—Carbide in 100 lb. cans is easily obtainable anywhere in the United States and usually costs from $5.00 to $6.00 per 100 lbs. in small lots, and less in ton lots. 100 lbs. carbide is equivalent to 500 feet of Acetylene Gas.

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THE LINDE AIR PRODUCTS CO.

Carbide and Carbon Building, 30 East 42nd Street, New York

For Information Regarding Prices, Terms, Etc., Communicate With Our Nearest District Sales Office, Located in Any One of the Following Cities

ATLANTA, GA.
BALTIMORE, MD.
BOSTON, MASS.
BUFFALO, N. Y.
CHICAGO, ILL.
CLEVELAND, O.
DALLAS, TEXAS
DETROIT, MICH.
KANSAS CITY, MO.
MILWAUKEE, WIS.
NEW YORK, N. Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
ST. LOUIS, MO.
SAN FRANCISCO, CAL.

LINDE OXYGEN

Linde Oxygen

Is manufactured under the world renowned Linde Process, which first made oxygen a commercial possibility and which insures to the user of oxygen a gas of the **highest possible uniform commercial purity.**

Uses for Linde Oxygen

Linde oxygen is used extensively in many different metal welding and cutting processes, which makes it a necessity in and around the mine.

Linde Oxygen Cylinders

Linde Oxygen is compressed, stored and transported in steel cylinders, constructed in compliance with the requirements of the Inter-State Commerce Commission. The cylinders are of two sizes, with **capacities of 110 and 220 cubic feet,** respectively, charged to a pressure of 2000 pounds, with the gas at a temperature of 70° Fahrenheit. The operation is checked three times, to insure the full indicated amount of oxygen in each cylinder.

Customers Buy Oxygen—Not Cylinders

Linde customers are entitled to the free use of as many clinders as their oxygen requirements demand, with the understanding that they are to be returned within 30 days from date of shipment, after which time they are subject to a rental charge of 25 cents per week per cylinder. Under this arrangement the user is relieved of all expense incidental to the purchase of cylinders and their upkeep, as well as any possible bother incidental to compliance with I. C. C. or shipping regulations.

Distribution

Linde oxygen is distributed from our nation-wide chain of 82 plants and warehouses, located in every big industrial district in the country, where a large supply of filled cylinders is maintained at all times, thus insuring prompt delivery in any quantities, when and where wanted.

How to Order

To save time and insure prompt shipments, orders should be addressed to the Linde Air Products Co. at the nearest Distributing Station given in the list below.

DISTRIBUTING STATIONS

Albany, N. Y.
Allentown, Pa.
Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Brooklyn, N. Y.
Buffalo, N. Y.
Canton, O.
Charleston, W. Va.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, O.
Cleveland, O.
Columbus, O.
Dallas, Texas
Davenport, Ia.
Dayton, O.
Denver, Colo.
Des Moines, Ia.
Detroit, Mich.
Duluth, Minn.
E. Chicago, Ill.
Elizabeth, N. J.
Erie, Pa.
Ft. Wayne, Ind.
Galveston, Texas
Gr. Rapids, Mich.
Hammond, Ind.
Hartford, Conn.
Houston, Texas
Indianapolis, Ind.
Indian Orchard, Mass.
Jacksonville, Fla.
Johnstown, Pa.
Lima, O.
Little Rock, Ark.
Louisville, Ky.
Manitowoc, Wis.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Mobile, Ala.
Muskegon, Mich.
Nashville, Tenn.
New Orleans, La.
New York, N. Y.
Norfolk, Va.
No. Kansas City, Mo.
Oklahoma City, Okla.
Omaha, Nebr.
Peoria, Ill.
Philadelphia, Pa.
Pittsburgh, Pa.
Port Arthur, Texas
Reading, Pa.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
San Antonio, Texas
Savannah, Ga.
Scranton, Pa.
Shreveport, La.
Terre Haute, Ind.
Toledo, O.
Trafford, Pa.
Tulsa, Okla.
Utica, N. Y.
Washington, D. C.
Wheeling, W. Va.
Wichita, Kan.
Worcester, Mass.
Youngstown, O.

PACIFIC COAST

Emeryville, Cal.
San Francisco, Cal.
Los Angeles, Cal.
Seattle, Wash.
Portland, Ore.
So. San Francisco, Cal.
Salt Lake City, Utah
Spokane, Wash.
San Diego, Cal.

THE LARGEST PRODUCER OF OXYGEN IN THE WORLD

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THE PREST-O-LITE COMPANY, Inc.

General Offices

Carbide and Carbon Building, 30 East 42nd Street, New York

Balfour Bldg., San Francisco; In Canada: Prest-O-Lite Company of Canada, Ltd., Toronto

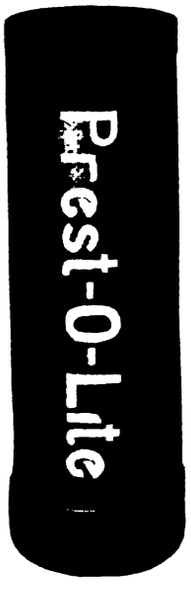
For Information About Our Latest Sales and Service Plans Communicate With Our Nearest District Sales Office, Located in One of the Following Cities

PITTSBURGH, PA.	CLEVELAND, O.	PHILADELPHIA, PA.	NEW YORK, N. Y.
BUFFALO, N. Y.	ATLANTA, GA.	ST. LOUIS, MO.	BALTIMORE, MD.
MILWAUKEE, WIS.	SAN FRANCISCO, CAL.	BOSTON, MASS.	KANSAS CITY, MO.
CHICAGO, ILL.	DALLAS, TEXAS	DETROIT, MICH.	

PREST-O-LITE
DISSOLVED ACETYLENE
The Universal Gas with the Universal Service

Prest-O-Lite

Dissolved Acetylene, for Oxy-Acetylene Welding and Cutting.



Prest-O-Lite is not merely a "Tank" and not merely a "gas"; it is a complete, permanent, dependable and universal system of dissolved acetylene service, which provides the highest grade of Dissolved Acetylene (ready-made carbide gas), compressed into portable cylinders of convenient size.

Uses for Prest-O-Lite

The test of time has proven Acetylene to be the **only practical welding gas** and by far the best cutting gas. In conjunction with oxygen, it is indispensable in the mine in connection with iron and steel construction work; repairing broken or worn metal machine parts and tools; reclaiming and repairing defective and broken castings.

Advantages of Prest-O-Lite

Prest-O-Lite cylinders have passed the rigid examination of the National Board of Fire Underwriters and their installation is permitted on insured premises. They are equipped with safety plugs to meet any fire emergencies and to satisfy all requirements of the Inter-State Commerce Commission, insurance authorities, etc. They are freely accepted for transportation by freight or express and may be used with every assurance of safety.

Prest-O-Lite Cylinders

Are not merely hollow steel shells filled with acetylene gas. The cylinders are filled with a porous substance, saturated with a liquid chemical which absorbs about 25 times its own volume of acetylene at atmospheric pressure. When pressure is applied during charging, the chemical continues absorbing acetylene in this proportion for every atmosphere of increased pressure, which explains the large capacity of a Prest-O-Lite. Every cylinder is fully tested and charged in accordance with Inter-State Commerce Commission regulations.

How Prest-O-Lite Is Supplied

Prest-O-Lite is supplied in two size cylinders: Style "WC", of 100 cu. ft. capacity, and Style "WK", of 300 cu. ft. capacity. Prest-O-Lite is distributed under a system whereby the holder of an exhausted cylinder may promptly exchange it for another Prest-O-Lite of like size, fully charged and ready for use.

When a Prest-O-Lite is exhausted of its acetylene contents, send it or take it to the nearest Distributing Station shown in the list below and receive a new one in exchange, upon payment of a moderate exchange fee. A net-work of 54 plants and warehouses insures prompt and dependable service at all times.

DISTRIBUTING STATIONS

Allentown, Pa.	Cincinnati, O.	East Peoria, Ill.	New Orleans, La.	St. Louis Pk., Minn.
Atlanta, Ga.	Cleveland, O.	Elkton, Md.	New York, N. Y.	Speedway, Ind.
Baltimore, Md.	Columbus, O.	Galveston, Texas	Norfolk, Va.	Terre Haute, Ind.
Birmingham, Ala.	Dallas, Texas	Gr. Rapids, Mich.	No. Kansas City, Mo.	Toledo, O.
Buffalo, N. Y.	Davenport, Ia.	Hammond, Ind.	Omaha, Neb.	Tulsa, Okla.
Cambridge, Mass.	Denver, Colo.	Ind. Orchard, Mass.	Philadelphia, Pa.	Utica, N. Y.
Canton, O.	Des Moines, Ia.	Louisville, Ky.	Pittsburgh, Pa.	Washington, D. C.
Charleston, W. Va.	Detroit, Mich.	Milwaukee, Wis.	Richmond, Va.	Wichita, Kan.
Chicago, Ill.	Duluth, Minn.	Newark, N. J.	St. Louis, Mo.	Youngstown, O.

PACIFIC COAST

Los Angeles, Cal.	Seattle, Wash.	Salt Lake City, Utah
San Francisco, Cal.	Portland, Ore.	Spokane, Wash.
Oakland, Cal.	So. San Francisco, Cal.	San Diego, Cal.

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OXWELD ACETYLENE COMPANY

NEWARK CHICAGO SAN FRANCISCO

Oxwelding and Cutting Process

The Oxweld Process

The Oxweld Process of welding and cutting metal by means of the oxy-acetylene flame affords the mine operator a simple and efficient means of making quick repairs which can be utilized by the average workman after a little instruction.

Oxweld equipment embraces all the necessary apparatus to perform every operation within the range of the Oxy-acetylene Process.

Practically any metal can be welded with this process. Two inexpensive gases—acetylene and oxygen—are combined in a suitably designed blowpipe to produce a small flame developing a degree of heat far greater than that produced by any gaseous or solid fuel. This high temperature flame (6300 degrees, F.) is easily controlled and may be applied locally in as small or large a volume as desired. The effect of this tremendous heat is to bring the edges of the two pieces of metal to a molten state, so that with filling material of the same kind as the metal worked upon, the whole can be welded into one continuous piece, possessing practically the same strength as the original piece.

The Oxweld Cutting Process can be applied to cutting wrought iron and steel plate, structural steel work and steel castings. The procedure is to first preheat the metal to be cut by a jet of mixed oxygen and acetylene, then by directing a jet of oxygen upon it, the spot is ignited and blown away in the form of iron oxide. A narrow, clean slot, cut through the section, is the result. The action is so rapid that the heat is confined to the edges of the cut to be made and the metal neither melted nor injured in any way. The edges present the clean metallic surface of a saw cut. In this manner, metals up to 14″ thick may be cut rapidly and smoothly along any given line—circle, curve, profile or bevel, the kerf being not over ⅛ to ¼-inch wide. **Cast iron is also cut by the same blowpipe.**

Applications of the Oxweld Process

OXWELDING—Boiler tubes; tube sheets; flues and seams; fire doors; cracked cylinders, pistons, valve chests; pump castings broken in service; reclaiming flywheels and gears; superheater lines; receivers; connections for feed water heaters.

Rail bonding; motor housings; building teeth on defective pinions and gears; armor for shafts; copper wires and cables; transformer cases; meter and instrument connections.

Iron and steel pipe lines for the transmission of air, gas, steam and water; headers and special fittings, such as T's, S's and Y's; traps and coils.

General repairs to steel mine cars; mine car axles and wheels; hitchings; locomotive frames, pins, links, spokes, etc.; repairing storage batteries, frogs and crossings.

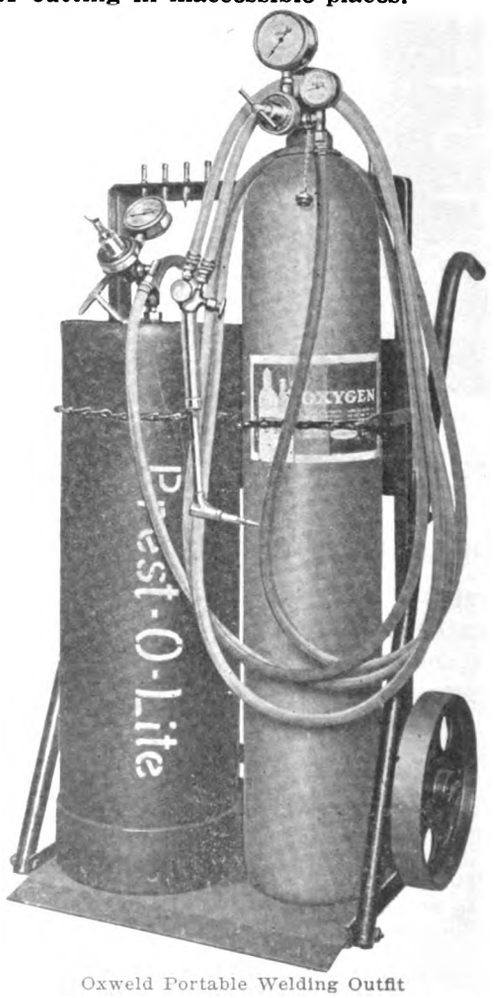
Filling up blow holes, porous spots, cracks, and breaks in castings of all kinds.

CUTTING—Plates; structural shapes; bars and rods; rails; pipes; cutting out rivets; wrecking; cast iron pots; floor plates; hubs of gears and fly wheels, etc.

Oxweld Welding and Cutting Units

The type shown below provides a portable welding and cutting unit in compact and efficient form. With this equipment the same blow pipes are used as with the generator plants and the same character of work is done.

This unit is valuable for emergency repair work and for cutting in inaccessible places.



Oxweld Portable Welding Outfit

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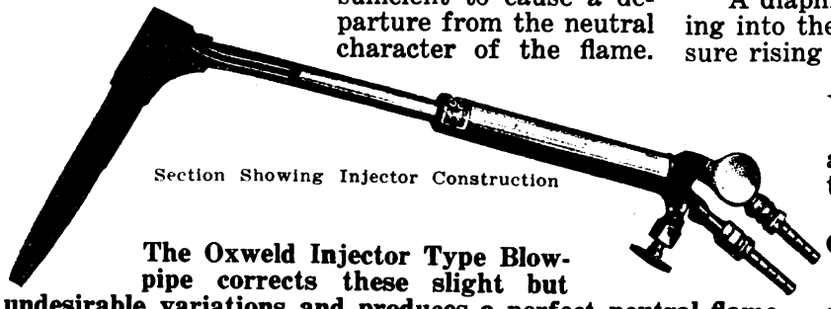
Equipment

An Oxweld Welding Unit consists of:
1 welding blow pipe with 5 heads
1 oxygen regulator with two gauges
1 acetylene regulator with tank gauges
1 adapter for acetylene tank
2 fifteen-foot lengths of high pressure hose
2 pairs darkened spectacles
1 truck Wrenches, hose clamps, etc.

An Oxweld Cutting Outfit consists of:
1 cutting blow pipe with 4 nozzles
1 oxygen cutting regulator with 2 gauges
1 acetylene regulator with tank gauge
1 adapter for acetylene tank
1 fifteen-foot length of high pressure hose
1 fifteen-foot length of armored high pressure hose
2 pairs darkened spectacles
1 truck Wrenches, hose clamps, etc.

Oxweld Welding Blowpipes

The Oxweld Blowpipe is a high efficiency torch of the injector type. It was developed to avoid the defects of the pressure type. The acetylene is drawn into the combining tube by the injector action of the high pressure oxygen jet, in correct quantity to combine chemically with the acetylene, forming what is known as a neutral flame, having an excess of neither acetylene or oxygen. With the best equipment available there are slight and unavoidable variations in the pressure of the oxygen as it leaves the regulator, and in the acetylene when generated in the so-called pressure type of generator or when drawn from cylinders. These variations are not noticeable on the gauge, but are sufficient to cause a departure from the neutral character of the flame.



Section Showing Injector Construction

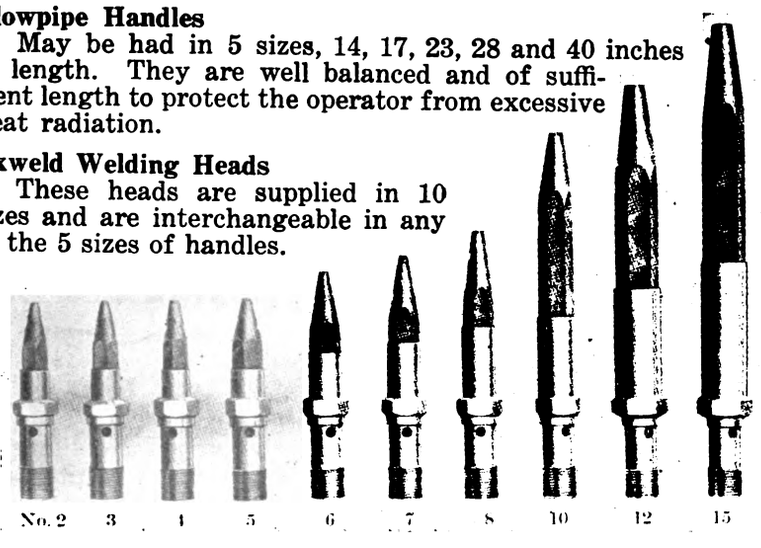
The Oxweld Injector Type Blowpipe corrects these slight but undesirable variations and produces a perfect neutral flame.

Blowpipe Handles

May be had in 5 sizes, 14, 17, 23, 28 and 40 inches in length. They are well balanced and of sufficient length to protect the operator from excessive heat radiation.

Oxweld Welding Heads

These heads are supplied in 10 sizes and are interchangeable in any of the 5 sizes of handles.



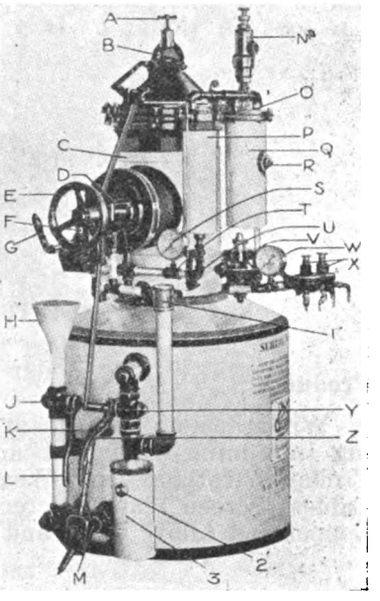
Oxweld Portable Acetylene Generator

This generator is designed primarily for installations where it is necessary to move the generator to various points for operation. It can also be used as a stationary generator.

The Portable Outfit consists of a single shell containing both the carbide hopper and generating tank. There is no gasometer, the carbide feeding mechanism being controlled by the pressure of the generator gas against a flexible diaphragm.

The feeding mechanism is positive in action and is provided with an automatic no-pressure stop mechanism, which closes the feed opening in case the pressure in the generator is reduced to zero, due to a leak in the line, or other cause.

A locking hand wheel positively locks the feed mechanism in its closed position when the generator is not in service.



Oxweld Portable Generator

A complete system of interference devices connecting the filling cap, feed mechanism, and residuum gate, provides against mistakes in operation.

A diaphragm relief valve is provided, discharging into the atmosphere, which prevents the pressure rising above normal.

The usual Hydraulic Back Pressure Valve is provided.

For easy transportation, the generator may be mounted on a four-wheel truck.

Oxweld Cutting Blowpipes

In Oxweld construction the preheating flame entirely surrounds the oxygen cutting jet. This flame is delivered through 6 openings arranged in circular form around the orifice discharging the high pressure oxygen jet. This enables the preheating flame to always precede the oxygen cutting jet, without turning the blowpipe or causing the operator to change his position. The Injector principle is used in this blowpipe as in the Welding Blowpipe. A separate regulating valve controls the oxygen supply to the preheating flame, permitting closer adjustment of the flame to the work in hand.

Oxweld Cutting Blowpipes are adapted for cutting metals from 1/8 to 12 inches in thickness.

All Oxweld Apparatus is tested and listed as standard by the Underwriters' Laboratories for installation on insured premises.

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THE AMERICAN BRASS COMPANY

General Offices: WATERBURY, CONN, U. S. A.

Mills and Factories

ANSONIA, CONN. BUFFALO, N. Y. KENOSHA, WIS. TORRINGTON, CONN.
WATERBURY, CONN.

Anaconda Copper and Brass Products

Products

Wrought non-ferrous materials for manufacturing into mine equipment and supplies, including Trolley Wire; Bare and Weather-Proof Wires and Cables; Screen Plates; Screen Wire; Pipe—Brass, Copper and Alloy; Brass and Bronze Products.

Copper Wire and Cable

Hard drawn Copper trolley wire, round, grooved, figure 8 and special patterns.

Special alloy trolley wire of extra high tensile strength for especially hard usage.

Bare and weatherproof copper wires and cables for power transmission. All cables are made under rigid specifications and thoroughly tested to give maximum tensile strength consistent with high conductivity. When so required, each wire will be made continuous without a splice throughout each length of cable.

Plates for Screens

While The American Brass Company does not furnish perforated metal screen plates, it has for many years manufactured special alloy sheets from which screen plates and chutes are made. Of these alloys Anaconda Manganese Bronze and Ambrac Metal are particularly resistant to the corrosive action of mine waters and withstand abrasion exceedingly well.

When ordering screen plates, specify American Brass stock which is made from the highest grade materials and sold under the Anaconda Trade Mark, a symbol of quality control.

Wire for Screens

Anaconda quality products also include copper, bronze and Ambrac Metal wire made especially for weaving into screens. Where exact requirements are known these wires can be produced to give the maximum service possible under the specific condition of use.

Tobin Bronze

For twenty-five years The American Brass Company has been manufacturing Tobin Bronze by special processes. This alloy, on account of its resistance to corrosion, high tensile strength, uniformity of texture and ease of machining, has been considered the best material obtainable for pump liners, piston rods, and other mechanical construction which operate in contact with water. Tobin Bronze rods and shafting are so made as to be thoroughly worked from the core to the outside surface, and have a uniform hardness and an even distribution of internal strains. Repeated investigations have proven that Tobin Bronze products are in every way more dependable than the so-called equivalents.

Anaconda Pipe for Water Service

The American Brass Company makes a specialty of manufacturing wrought, non-ferrous seamless pipe in standard pipe sizes, that is, the same sizes used for iron pipe, either regular or extra heavy. Such pipe is trademarked "Anaconda" and made from brass, copper, Ambrac Metal, or special alloys to meet specific requirements.

These different classes of pipe will not rust or clog and are guaranteed not to split. The corrosion resisting qualities of Anaconda special alloys, and the acid resisting qualities of Ambrac Metal make them especially desirable for mine uses.

General Products

In addition to the above mentioned materials, The American Brass Company manufactures Brass, Copper and Nickel Silver in every variety of sheet, wire, rods and tubes.

Service

The benefits of a fully equipped Metallurgical Department are offered those who are interested in technical problems.

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THE INTERNATIONAL NICKEL CO.

General Offices

67 Wall St., NEW YORK, N. Y.

Products

Metallic Nickel—Shot, Ingot, Electrolytic 99.8%.

Malleable Nickel—All Commercial Forms.

Monel Metal—All Commercial Forms.

Uses in the Mining Industry

Screens	Chutes	Tanks
Pumps	Pump Rods	Pump Liners
Pump Shafts	Pump Valves	Pump Glands
Turbines	Impellers	Nozzles
Tie Rods	Tubing	Valves
Fittings	Fans	Blowers
Gaskets	Filters	Filter Cloth
Washers	Bolts	Nuts
Screws	Rivets	Perforated Metal
Wire Rope	Valve Trim	Ball Bearings

Technical Research

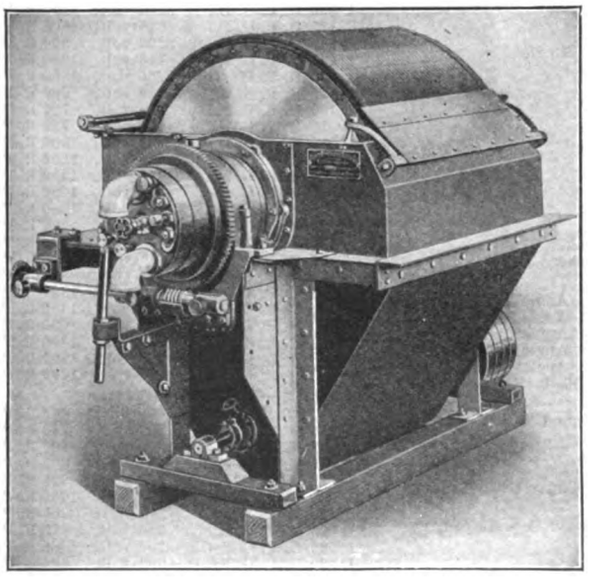
The International Nickel Company maintains a technical staff and laboratories for the purpose of testing its products under various conditions, and our engineers are glad to co-operate in the development of any new applications of Monel metal or nickel and to assist in the extension of present uses.

Monel Metal

An alloy of 67% nickel, 28% copper and 5% other metals.

Unique Combination of Properties

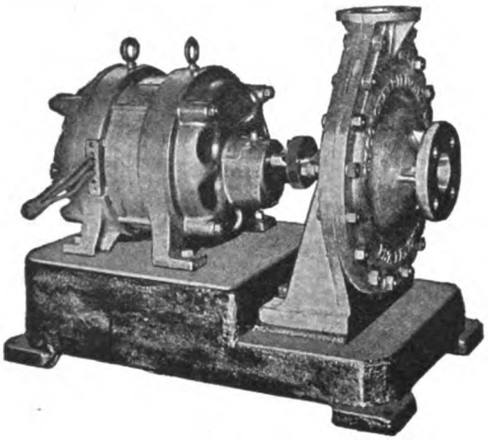
The combined qualities of Monel metal—strength of steel, corrosion resistance and ability to withstand abrasion—will help to solve your metal problems.



Oliver Monel Metal Filter for Corrosive Materials

Literature

Instruction sheets on various methods of working Monel metal can be had on application, also general booklets descriptive of Monel metal and nickel products. We have in course of preparation a series of booklets with reference to the use of Monel metal in the different industries, any or all of which we shall be glad to supply as soon as available.



Monel Metal Pump, Chemical Equipment Co., Chicago

Monel Metal Distributors

WHITEHEAD METAL PRODUCTS CO.
67 Washington Street, N., Boston, Mass.

WHITEHEAD METAL PRODUCTS COMPANY OF NEW YORK, INC.
261 Canal Street, New York, N. Y.
Branch at—43 North Seventh Street, Philadelphia, Pa.

WILLIAMS AND COMPANY, INC.
901 Pennsylvania Avenue, Pittsburgh, Pa.

STEEL SALES CORPORATION
129 South Jefferson Street, Chicago, Ill.

PACIFIC FOUNDRY COMPANY
Harrison and Eighteenth Streets, San Francisco, Cal.

EAGLE BRASS FOUNDRY COMPANY
21 Spokane Street, Seattle, Wash.

EDW. SCHWARTZ MILL SUPPLY CO., INC.
520 Toulouse Street, New Orleans, La.

PECKOVER'S, LTD.
Foot of West Market Street, Toronto, Canada.

ROBERT W. BARTRAM
129 Duke Street, Montreal, Canada.

Some Well Known Users Are

Lehigh Coal & Navigation Co.
Trevorton Colliery Co.
Anaconda Copper Co.
Nichols Copper Co.
Calumet & Hecla Mining Co.
Deloro Smelting & Refining Co.
Wellman-Seaver-Morgan Co.
Worthington Pump & Machinery Corp.
General Electric Co.
Westinghouse Electric & Mfg. Co.
The Lunkenheimer Co.
Hendrick Mfg. Co.
Cross Engineering Co.

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The Morse Bros. Machinery & Supply Co.

DENVER, COLORADO

Used Machinery

For Mines, Mills, Smelters and Power Plants

Products

Machinery—New and Second Hand; Filter Presses; Filters—Continuous Vacuum; Thickeners—Pulp; Tanks—Wood and Steel; Crushers—Jaw and Gyratory; Crusher Rolls; Mills—Ball and Tube; Classifiers—Hydraulic and Mechanical; Concentrating Tables; Concentrating Machinery; Dryers—Rotary; Furnaces—Blast; Converters—Copper; Pumps—Power, Steam and Sinking; Rails; Drills—Core and Diamond; Tramways—Aerial; Dredges—Hydraulic; Hoists—Steam; Compressors—Air (New and Second Hand); Locomotives—Electric; Motors and Generators—New and Second Hand; Water Wheels.

You can always **save money** and get **immediate shipment** on Used Machinery. All of our machinery is carefully gone over in our shops to insure everything being in good working condition and to see that it is complete with all fittings and parts.

The following list gives you an idea of what our stock includes. It is not a complete list, but shows such items as we usually have in stock.

FILTERS.

1—14'x12½' Portland.
1—14'x12' Oliver.
4—12'x9' Portland.
2—12'x8' Portland.
1—12'x7½' Portland.
2—No. 850 Kelly Filters.
6—No. 450 Kelly Filters.
1—24"x24" Perrin, 55 plates.
1—24"x24" Johnson, 55 plates.
11—6'x6' Filter Leaves.
12—5.4"x4.6" Filter Leaves.

THICKENER MECHANISMS.

4—40'x7' Thickener Mechanisms, with steel tank.
2—40'x12' Thickener Mechanisms, with trays.
2—36'x12' Thickener Mechanisms, with trays.
3—32' dia. Thickener Mechanisms, only.
2—30'x10' Thickener Mechanisms, with steel tanks.
3—28' dia. Thickener Mechanisms, only.
1—18' dia. Thickener Mechanisms, only.
We have a large number of both steel and wood tanks which we can arrange for use with above.

CRUSHERS.

1—15x24 Blake. 2—4½x6 Dodge.
1—10x20 Blake. 1—No. 7½ Austin Gyratory.
4— 9x15 Blake. 1—No. 5 Austin Gyratory.
2— 7x10 Blake. 2—No. 4 Gates Gyratory.
1— 4x10 Blake. 1—No. 1 Gates Gyratory.
1— 7x10 Dodge. 1—No. 3 Samson.

ROLLS.

1—Set 36x16 Power & Mining Machy. Co.
1—Set 36x16 Davis.
2—Set 30x14 Power & Mining Machy. Co.
1—Set 27x14 McFarlane.
2—Set 27x14 Davis.
1—Set 27x14 Walker.
3—Set 20x12 McFarlane.
2—Set 20x12 Stearns-Roger.

BALL MILLS.

1—8'x6' Gates. 2—5'x4' Standard.
1—6'x6' Allis Chalmers. 1—4'x4' Standard.
4—5½x6' Standard. 2—4'x3' Standard.
1—6'x16" Hardinge. 1—3'x3' Standard.

TUBE MILLS.

2—5'x22' Allis Chalmers, Steel Lined.
1—5'x16' Allis Chalmers, Silex Lined.
1—5'x14' Allis Chalmers, Silex Lined.
1—6'x12' Allis Chalmers, Silex Lined.
2—4½'x12' Allis Chalmers, Silex Lined.

CLASSIFIERS.

7—45-in. Akins.
3—Model C Dorr Duplex—19 ft. 8 in. long.
1—Model C Dorr Duplex—Standard length.
1—Allis-Chalmers Annular Classifier.
1—Richards Vortex Classifier.
1—4-in. Richards Pulsator Classifier.

CONCENTRATORS.

10—No. 5 Wilfley Tables.
6—No. 6 Wilfley Pattern Tables, new.
12—Model C, Card Concentrators.
1—No. 2 Deister Concentrator.
12—6' Allis Chalmers Frue Vanners.

DRYERS REVOLVING.

1—54"x22' Revolving Dryer.
1—36"x20' Revolving Dryer.
1—30"x18' Revolving Dryer.

SMELTING EQUIPMENT.

1—42"x120" Taylor Copper Matting Furnace.
1—42"x120" Davis Copper Matting Furnace.
1—38"x96" Davis Copper Matting Furnace.
1—42" Round Copper Matting Furnace.
2—Copper Converters with Stands.

PUMPS—Power.

1—6¼x4 7/8x24 Reidler, Horizontal.
3—10x10 Deane. Vertical Triplex.
1— 9x10 Deane. Vertical Triplex.
1— 8x12 Gould. Vertical Triplex, Double Acting.
3—1½x12 Dean Horizontal, Double Acting.
1—8 x10 Deming Vertical Triplex.
1—7 x 8 Platt Vertical Triplex.
1—5½x 8 Deming Vertical Triplex.
2—5 x 8 Deane Vertical Triplex.
1—5 x 6 Aldrich Horizontal Triplex.
1—3½x 6 Gould Vertical.
1—5 H. P. F. M. Gasoline Geared Pumping Engine. Cap. 125 G. P. M.

PUMPS—Steam, outside packed.

1—15 and 26x8x24 Knowles Duplex Compound.
6—14 and 20x7½x19 Worthington Duplex Compound.
10—25 and 38x4⅝x24 Worthington Duplex Compound.
1—9 and 14x10x12 Smith Vaile Duplex Compound.
1—14x6x12 Knowles, Single.
1—10x6x12 Jeanesville, Duplex.
1— 9x5x10 Buffalo, Duplex.
1— 6x4x 6 F-M Duplex.
1— 6x4x 6 Knowles, Duplex.
1— 6x3x 6 F-M Duplex.

PUMPS—Steam—General Service.

1—14 and 20x10x18 F-M Duplex Compound.
1—14x10½x12 Knowles Duplex.
1—14x10x10 Deane, Duplex.
1—14x18½x12 Snow, Duplex.
2—14x7x12 F-M Duplex.
1—12x7x12 Snow, Duplex.
1—10x6x12 F-M, Duplex.
1—10x6x10 Snow, Duplex.
1—8x6x10 Snow, Duplex.
1—12x5x12 Snow, Duplex.
1—8x8x12 F-M, Duplex.
1—8x5x12 F-M, Duplex.
1—7½x4½x10 Deane, Duplex.
8—6x4x6 Duplex Pumps.
1—5¼x3½x5 Deane Duplex.
1—4½x3x4 F-M, Duplex.
1—16x8x20 Hooker, Single.
1—16x8x12 Knowles, Single.
1—10x8x12 Marsh, Single.
1—10x5x12 Davidson, Single.
1—7x4½x10 Card & Weber, Single.
2—No. 5 Cameron.
2—No. 3 Knowles.

SINKING PUMPS.

2—No. 11 Cameron.
3—No. 9B Cameron.
1—No. 8 Cameron.
3—No. 7 Cameron.
1—10x5x12 Snow, Duplex.
1—7x3½x10 Snow, Duplex.
3—No. 5 Cameron.
1—5x6 Knowles Electric Sinker.
1—4½x6 Gould Electric Sinker.

RAIL.

10000—Ton 60-lb. Rail with Angle Bars.
600—Ton 56-lb. Rail with Angle Bars.
1850—Ton 50-lb. Rail with Angle Bars.
225—Ton 40-lb. Rail with Angle Bars.
1000—Ton 12-lb. Rail with Angle Bars.
7—No. 6 Switches, for 56-lb. Rail.

DIAMOND DRILLS.

1—Size "C" Sullivan Diamond Drill. Capacity 1,500' with rods.
1—Longyear Diamond Drill. Capacity 500', with rods.
1—Davis-Calyx Core drill. Capacity 350'.

TRAMWAYS.

1—16⅔ Mile Leschen Tramway. Cap. 40 tons.
1—8-mile. Same as above.
1—4-mile. Same as above.
1—1½-mile Leschen Tramway. Cap. 20 tons.
1—1-mile Bleichert Tramway. Cap. 10 tons.

DREDGE.

1—3½ cu. ft. Marion Gold Dredge. Electrically driven, or can arrange for steam power.

HOISTS—Steam.

1—16x24 Nelsonville, Double Drum.
1—10x12 H. & B., Double Drum.
1—14x18 Lidgerwood Single Drum.
1—11x15 Gates, Single Drum.
2—10x14 Davis, Single Drum.
1—10x12 Vulcan, Single Drum.
2— 8x10 Vulcan, Single Drum.
1— 6x 8 McFarlane, Single Drum.
4—6x 8 Double Friction, Single Drum.
1—5x 6 Davis, Single Drum.
1—Anaconda Prospectors Hoist.

HOISTS—Belt Driven.

1—Double Drum Hoist, Single Friction. Drums 16 in. x 23 in.
4—Single Drum Hoists, Double Friction.
2—Single Drum Hoists, Single Friction.

COMPRESSORS—Belt Driven.

2— 8x 8 Bury, Single Stage.
1—10x 8 Franklin, Single Stage, 116 c. f.
1—14x 9x11 Franklin Two Stage 314 c. f.
1—16x10x12 Ingersoll Two Stage 410 c. f.
1—16x10x18 Leyner Two Stage 481 c. f.
1—16x18 Ingersol, Single Stage 505 c. f.
1—25¼x14½x14 Ingersoll, Two Stage 1100 c.f.
1—22x13x36 Reidler, Two Stage 1400 c. f.
6—15x26x24 Laidlaw, Two Stage 2,570 c. f.

COMPRESSORS—Steam Driven.

1—6x6x6 Ingersoll Single Stage, 29 c. f.
1—14x14x22 Rand Single Stage, 391 c. f.
2—14½x16x10x17 Leyner Two Stage, 427 c. f.
1—14x16x9½x16 Norwalk Two Stage, 558 c.f.
1—16x18x11x22 Leyner Two Stage, 648 c. f.
2—9x17x15x9½x12 Laidlaw Two Stage, 623 c. f.
1—18x30x26x16x24 Laidlaw Two Stage, 1,314 c. f.
1—13x22x13x22x36 Reidler Two Stage, 1,400 c. f.
1—8x8x4½x2⅜x8 Clayton Co., 2 Compressor.

LOCOMOTIVES—Electric.

3—10-ton Gen. Electric 36-in. gauge, 250 volt.
2—6-ton Morgan Gardner, 24-in., 250 volt.

MOTORS—A. C.—3 ph. 60 cy.

1	300-H. P. G. E.,	2200-volt,	1800 R. P. M.
1	300-H. P. G. E.,	2200-volt,	1200 R. P. M.
3	175-H. P. G. E.,	440-volt,	600 R. P. M.
1	225-H. P. G. E.,	2200-volt,	900 R. P. M.
1	225-H. P. G. E.,	440-volt,	900 R. P. M.
1	150-H. P. West.,	2200-volt,	1800 R. P. M.
1	150-H. P. G. E.,	440-volt,	600 R. P. M.
1	100-H. P. G. E.,	440-volt,	720 R. P. M.
1	75-H. P. G. E.,	440-volt,	720 R. P. M.
1	75-H. P. G. E.,	440-volt,	900 R. P. M.
2	50-H. P. Al.-Ch.,	440-volt,	1200 R. P. M.
6	40-H. P. G. E.,	440-volt,	1200 R. P. M.
8	30-H. P. G. E.,	440-volt,	1200 R. P. M.
6	25-H. P. G. E.,	440-volt,	1200 R. P. M.
4	25-H. P. G. E.,	440-volt,	900 R. P. M.
3	20-H. P. G. E.,	440-volt,	900 R. P. M.
18	15-H. P. West.,	440-volt,	1200 R. P. M.
7	15-H. P. G. E.,	440-volt,	900 R. P. M.
8	10-H. P. West.,	440-volt,	1800 R. P. M.
5	10-H. P. G. E.,	440-volt,	1200 R. P. M.
10	10-H. P. G. E.,	440-volt,	900 R. P. M.
3	7½-H. P. G. E.,	220-volt,	1800 R. P. M.
12	7½-H. P. G. E.,	440-volt,	1200 R. P. M.
15	5-H. P. G. E.,	440-volt,	1200 R. P. M.

MOTORS—Direct Current.

1	133-H. P. West.,	500-volt,	600 R. P. M.
1	125-H. P. G. E.,	500-volt,	740 R. P. M.
1	95-H. P. G. E.,	500-volt,	700 R. P. M.
1	75-H. P. West.,	500-volt,	600 R. P. M.
1	55-H. P. G. E.,	500-volt,	925 R. P. M.
1	30-H. P. G. E.,	230-volt,	1000 R. P. M.
2	25-H. P. West.,	250-volt,	600 R. P. M.
1	25-H. P. G. E.,	500-volt,	415 R. P. M.
1	20-H. P. C. & C.,	250-volt,	1400 R. P. M.
1	20-H. P. G. E.,	500-volt,	600 R. P. M.
1	7½-H. P., West.,	230-volt,	Inclosed.

WATER WHEELS.

3—6' De Remer Double Nozzle.
6—5' De Remer Double Nozzle.
1—4' Hug Double Nozzle.
4—38" Leffell Single Nozzle.
1—3' Hug Single Nozzle.
1—24" Hug Single Nozzle.
1—18" Pelton Single Nozzle.

COMPLETE MACHINERY STOCK LIST SENT ON REQUEST

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THE SALT LAKE HARDWARE CO.

SALT LAKE CITY, UTAH POCATELLO, IDAHO

Distributors of

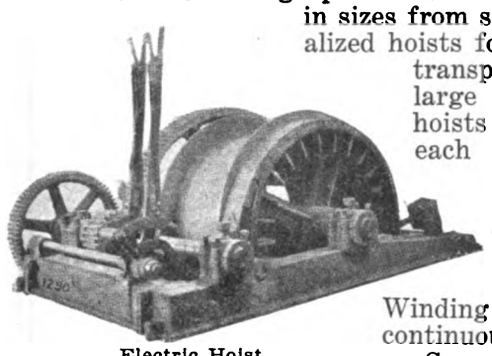
Mine, Mill and Smelter Machinery, and Supplies

Products

Wire Rope; Powder; Dynamite; Fuse; Belting; Mine Hose; Drill Steel; Picks; Ore Cars; Ventilation Equipment.

Electric Hoists

Denver Engineering Works Company. For metal and coal mining operations. Manufactured in sizes from small sectionalized hoists for mule-back transportation, to large heavy duty hoists designed for each installation. Single, double, or triple drum. Vertical or incline shafts. Winding engines for continuous haulage. See page 400.



Electric Hoist

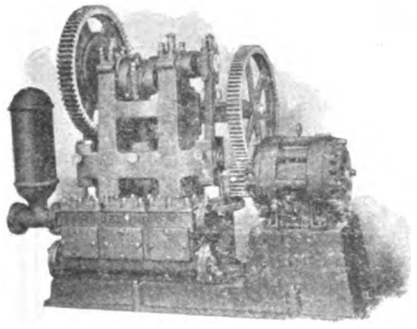
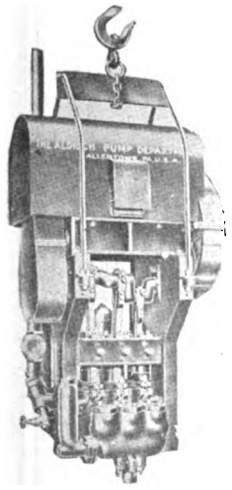


Fig. 50. Size 5½ x 8 to 8½ x 8, with Type "B" Drive. Capacity 5½ x 8 size, 8,800 gallons per hour.

Triplex Pumps

Deming. For Mine Station Service where large quantities of water are to be handled against high heads. Furnished in belted, geared, or silent chain motor drive.

For full description of Deming pumps see pages 456 and 457.



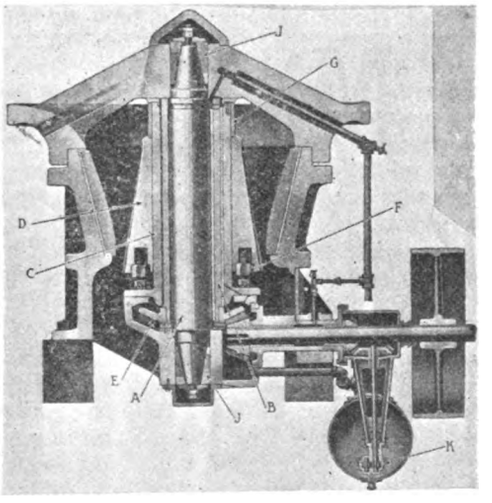
Double Reduction, Direct Geared

Electric Triplex Sinking Pumps

Aldrich Pump Company. In scarcely any case are the demands on a pump so severe as in mine sinking. The conditions are essentially such that it is extremely difficult to hold the pump securely while in operation and the working parts are often partially or entirely submerged. There is also a constant falling of grit and dirt, and the water pumped is always extremely muddy or gritty and sometimes acidulous.

The Aldrich Electric Triplex Sinking Pump is designed to meet all these conditions.

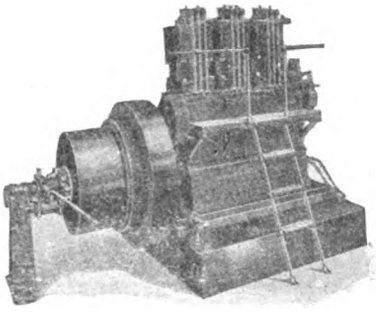
For full description of Aldrich Pumps see pages 452 and 453.



Primary Breaker

Primary Breakers

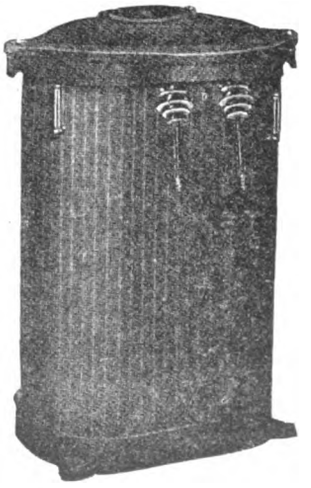
Smith Engineering Works. Telsmith Primary Breakers, sturdy and efficient, for initial crushing or the breaking of the mine-run into coarse pieces. Write for Bulletin.



Diesel Engine

Western Diesel Engine

Western Machinery Company. An internal combustion engine of the vertical 4-cycle enclosed crank case, medium speed, Diesel type. Embodies exceptionally high efficiency and fuel economy. Write for Catalog.



Moloney Transformer.

Transformers

Moloney Electric Co. More active copper and iron, with resultant overload carrying capacity and lower operating temperatures, characterize Moloney Transformers.

For full description of Moloney Transformers see page 261.

"EVERYTHING IN HARDWARE"

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SECTION XXIV

Mine and Mill Supplies

FOR INDEX TO ALL ENGINEERING DATA SEE PAGES 5 TO 12.

THE FOLLOWING MANUFACTURERS AND DEALERS ARE REPRESENTED IN THIS SECTION

Byers, A. M. Co.
Colonial Supply Co.
Duff Mfg. Co.
Goodrich, B. F. Rubber Co., The
Indiana Foundry Co., Inc.

FOR LIST OF EQUIPMENT USED IN MINING AND QUARRYING
SEE PRODUCTS INDEX (Blue Sheets)

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WAREHOUSE RECORDS

The following warehouse records have been taken from McGarraugh's Mine Bookkeeping (McGraw-Hill Book Co.) and represents a system suitable for small and moderately sized mines. The Stock on Hand Index, Warehouse Requisitions and Supplies Distribution are essential records; the Subsidiary records are: Way-bills; Requisitions for Bills-of-Material; Materials Returned and Inventories.

Way-bills (Fig. 21)

Where the mine is located at a distance from the railroad, a representative must be arranged for at the railroad station to receive freight and to forward it to the mine. If ore shipments are made, he arranges for cars and attends to the loading and shipping of the ore to the smelter. At small stations the railroad agent is usually employed to look after the company's shipping. This representative, or forwarding agent as he is called, advises the general office by mail or telephone concerning the contents of each shipment of supplies as received at the station. He supervises the loading of freight for transportatiton to the mine and furnishes each freighter with a way-bill for the contents of his load. The way-bill states the number of pieces, as barrels, boxes, sacks, etc., which each freighter has received, together with the contents, gross weight and destination of each item. The way-bills are numbered and are made out in triplicate; the original is given to the freighter, one copy is mailed to the mine office, and the other is held by the agent. All three copies are signed by the freighter upon receiving his load. When the freight is delivered at the warehouse the clerk checks the way-bill with the load as received and files it. The freighter is issued an order upon the cashier for the amount due, if the hauling is done by contract. The warehouse clerk should be provided with forms for notifying the general office of all supplies received.

Virginia M. & M. Co. Way-bill No. 2748

The following freight has been delivered to..... Date May 26, 192-

Forwarding Agt.

No.	Description	Contents	Gross wt.	Deliver at
6	Kegs	Nails	652	Mine warehouse
5	Bbls.	Oil	1820	Mine warehouse
1	Bbl.	Oil (leaking)	340	Mine warehouse
12	Cases	Dynamite	846	Magazine
			3658	

Received..... Freighter

Delivered..... Warehouse Clerk

FIG. 21.—Way-bill.

Stock on Hand Index (Fig. 22)

The object of this record is to show at all times the stock of supplies and materials on hand at the warehouse for which it is kept. A card index is usually used for this purpose; a separate card is kept for each size and variety of every kind of material or article in stock. Warehouse issues are posted directly to the Stock Cards from the Warehouse Requisitions. With items of stock which are constantly being issued in small quantities, as nails, waste, etc., the necessity of making many entries upon the stock cards can be avoided by charging out such articles upon the cards to a reserve stock in sufficient quantity to last for several days at the normal rate of consumption. New stock is entered upon the cards when received at the warehouse. On the example of Stock Card shown in Fig. 22 the symbol + is used to denote new stock received and — to denote stock issued; the warehouse inventory taken on Jan. 1st showed 167 lbs. 4″ wire nails in stock; on Jan. 2d 8 lbs. was issued, leaving 159 lbs. on hand; on the 3d 300 lbs. of new stock was received, making a total stock on hand of 459 lbs., etc. The unit cost is entered to the card from the Cost Book in pencil, so that the amount can be changed with each new shipment received. When the stock on hand falls below the minimum allowed, the clerk should notify the general office. Orders for warehouse stock should be made out or checked by someone who is familiar with the current needs, so that materials no longer used will be recognized and those for which the rate of consumption has changed may be ordered in quantities to meet present conditions.

Nails, 4″ Wire

Minimum Stock 100 lbs. — 4″ Wire Nails — Location in Warehouse G.19

Inv. — Unit-Lb. — Unit Cost $0.020 — 192-

1/1	167
—	8
1/2	159
+	300
1/3	459
—	6
1/3	453

FIG. 22.—Stock on Hand Index.

The warehouse clerk should be required to inventory parts of his stock from time to time, to see that the warehouse system is running smoothly and that his cards agree with the actual stock on hand. Only small discrepancies should occur, and these are corrected upon the cards as they appear, the general office being notified regarding shortages so that they may be charged out at the end of the month to the current operations. These charges for shortages in the warehouse stock may be distributed to the various accounts in the proportion of monthly distribution of the supplies issued.

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Stock Books (Fig 23)

At points where materials are kept on hand, but no clerk is employed, as at small outside prospects, etc., a card index will not be needed for keeping account of the supplies. The record will usually be kept by persons of little or no clerical ability, and a strong book, ruled off to suit the requirements, will be found more satisfactory. Fig. 23 shows a form of Stock Book of this kind. The book is kept in a similar manner to the stock cards, a full page or a part of a page being given to each item. Only important supplies should be carried in stock at such places, small items being charged out to the work at once whenever possible. The reports at the end of the month from these places should include an inventory of the actual stock on hand, so that the issues and receipts can be checked by the difference of the stock from month to month. As a rule, such records are kept in a more or less haphazard manner; they are usually subject to many errors and these must be hunted down at the office.

Article	Unit	Date 192–	Received	Issued	On Hand	Issued for what purpose
Blasting Caps, 5X	*each*	*2/4*	*800*		*800*	
		2/5		*100*	*700*	*To Simpson, contractor*
		2/6		*10*	*690*	*Development*
		2/8		*25*	*665*	"

Fig. 23.—Stock Book.

Warehouse Requisitions (Fig 24)

The issuing of materials and supplies from the general storehouse to the numerous ramifications of the work is one of the most potent sources of loss in the direction of mining operations. Workmen, as a class, are notoriously wasteful of company stores, and it is only by keeping a vigilant watch over the delivery of supplies that extravagance and waste, as well as dishonesty, can be prevented. The simple knowledge that a close check is being kept upon the materials issued will do much to promote economical methods. Supplies should be issued from the warehouse only upon the presentation of an order, made out and signed by a foreman or some other authorized person. However, care in the issuing of supplies does not imply needless formality or waste of workmen's time; the material called for should be dispatched from the warehouse with as little delay as possible when the requisition is delivered. These Warehouse Requisitions constitute the clerk's receipts for supplies issued; they should show a clear statement of the use to be made of the materials ordered. By using separate requisitions for materials to each subaccount, they can be segregated for convenient reference. At the end of the month they should be filed together in a binder, tab indexed to show the requisitions to each subaccount.

Foremen and workmen should be encouraged to practice rigid economy in the use of supplies; they should be made to feel that the consumption of warehouse stock is under the critical eye of the management, and that judgment and care in the use of supplies will be recognized and rewarded. If left to itself, a requisition system will invariably degenerate into a mere formality. The foreman is usually occupied with numerous duties and unless he makes a special effort to find out the purpose for which the supplies are intended and sees that they are used for that purpose the workmen soon learn that to obtain all the material wanted is only a matter of asking for the requisition.

Date April 9, 192–

Warehouse Clerk: Please deliver the following:

Article	Quantity	Amt.	Intended for what purpose	Group No.
¾" galv. pipe	40 ft.		Dwelling #34	17
¾" elbows	3		Dwelling #34	17
¾ tee	1		Dwelling #34	17

Note: Use for supplies to one subaccount only.

..... Account No. 612

Foreman

Fig. 24.—Warehouse Requisition.

Requisitions for Bills-of-Material

Bills-of-Material or Job Requisitions should be employed whenever they can be used. With this method the quantities of materials needed for any job are determined as exactly as possible, usually by the engineering department, and bill-of-material for the job is sent to the warehouse. The materials called for upon this statement are then subject to delivery to any responsible person, upon his giving a receipt. Spoiled material must be returned to the warehouse to be replaced, and material in excess of the amount stated upon the bill-of-material will not be issued without an explanation from the foreman and authorization from the office for the issue of the additional material required. No loss of time should be incurred by the application of this rule, as the foreman should be required to keep account of the condition of his allowance of materials and to give notice that an additional supply will be required before the deficiency occurs.

Supplies Distribution (Fig 25)

The object of this record is to make the final distribution of the daily issues of materials and supplies from the warehouse to the accounts benefitted. It also furnishes a permanent record of the materials used on each job or operation. The classification of supplies to be used with this record will vary with conditions; the following classification is given in the example shown in Fig. 25:

Group No.	Group.
1.	Bolts, nuts, washers, etc.
2.	Brick, cement, etc.
3.	Locomotive, car and truck parts.
4.	Carbide and candles.
5.	Chemicals.
6.	Drill parts.
7.	Drill steel.
8.	Explosives.
9.	Electrical supplies.
10.	Fuel.
11.	Iron and steel.
12.	Lumber and mine timber.
13.	Miscellaneous.
14.	Nails, screws, etc.
15.	Oils, grease, etc.
16.	Packing, waste, etc.
17.	Pipe and fittings.
18.	Tools.
19.	Track and supplies.

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A separate Supplies Distribution sheet is carried for each active account; these sheets are posted daily from the Warehouse Requisitions. From the Supplies Distribution the total warehouse charge for the month to each account is posted to the General Distribution sheet, which is carried at the general office. After the records have been closed at the end of the month, the Supplies Distribution sheets should be filed under the headings of the accounts, rather than by months, so that the costs of supplies and materials used on any job can be found without loss of time.

that the amount of actual shortage cannot easily be determined. By charging out the warehouse issues at cost, or at a fixed percentage above cost, a definite check on the warehouse issues can be obtained. Any difference at the end of the period between the inventory value and the book cost should be charged off to Profit and Loss, or it may be charged out at once or during the next period in the proportion of the material charged to the various accounts. If a "selling" percentage is added, it should be changed after each inventory to maintain the balance as closely as possible. The

SUPPLIES DISTRIBUTION — Month of September, 192—

Account ÷ Drills & Compressors

No.	Group	1	2	3	4	5	6	7	8	9	10	29	30	31	Adjustments	Total
1	*Bolts, Nuts, Washers, etc.*		0 67													
2	*Brick, Cement, etc.*															
3	*Loco., Car & Truck Parts*															
4	*Carbide & Candles*															
5	*Chemicals*															
6	*Drill Parts, etc.*	9 70		16 40												
7	*Drill Steel*															
8	*Explosives*															
9	*Electrical Supplies*															
10	*Fuel*															
11	*Iron & Steel*	2 00														
12	*Lumber & Timber*															
13	*Miscellaneous*															
14	*Nails, Screws, etc.*															
15	*Oils, Grease, etc.*	2 80	3 20	3 00												
16	*Packing, Waste, etc.*			4 25												
17	*Pipe & Fittings*															
18	*Tools*															
19	*Track & Supplies*															
	Totals															

FIG. 25.—Supplies Distribution.

Inventories

An inventory of all warehouse stock should be taken at regular intervals, usually twice yearly. Losses from handling, leakage, etc., are unavoidable, and to prevent any considerable difference between the book cost and the actual inventory value of stock on hand, a small percentage above cost may be allowed in charging out warehouse supplies; this should not exceed 5 per cent. and will usually be less. The percentage to be allowed may be changed from time to time in order to make the inventory value of the warehouse stock check out as closely as possible at the end of the period with the book cost. This method of an adjustable "selling" price has the disadvantage

principal items of supplies, as explosives, carbide, etc., should be inventoried at the end of each month and any shortage corrected by charging them out to the current accounts for the month.

Materials Returned

Materials are sometimes issued and not used, or they may be used for a time and then returned in good condition to the warehouse. A Materials Returned slip, preferably on colored paper, should be used to give credit to the proper accounts for supplies and materials returned to the warehouse. Credits entries for these items are made upon the Supplies Distribution and upon the General Distribution in red ink.

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A. M. BYERS COMPANY

Established 1864

PITTSBURGH, PA.

Genuine Wrought Iron Pipe, Couplings and Nipples

Black and Galvanized. Sizes, 1-4 in. to 12 in. Standard, Extra Heavy, Double Extra Heavy.

Look for the Name and Year rolled in every length

General

Owing to low price and ease of production, steel many years ago replaced wrought iron for the manufacture of wire, nails, sheets, rails and structural shapes. Such, however, is not the case with pipe, for the tonnage of Byers genuine wrought iron pipe continues to advance as its value for water, steam, and gas lines becomes more and more wideley recognized.

The reasons for the strong hold on consumers of genuine wrought iron pipe is that it possesses four cardinal features which differentiate it from steel pipe. While these features are common to all GENUINE wrought iron, it should be borne in mind that there are different qualities of wrought iron, and all do not possess these features to the same degree; also the name BYERS has been associated with the term GENUINE wrought iron for so long that today the two are synonymous.

The four features of Byers Pipe are as follows:

1. **Resistance to Corrosion**—Iron when taken out of the puddling furnace consists of a spongy mass of plastic iron globules thinly coated with slag or cinder. During the rolling process the globules become elongated and the slag takes the form of fine bands lying between the long iron fibres. This slag is composed of non-corrosive silicates.

It is due to the presence of more than 250,000 of these slag bands to every square inch of metal (cross-section) that Byers pipe shows such great resistance to corrosion. When corrosive agencies begin to act, more and more of the slag becomes exposed, and thus protects the underlying metal, considerably minimizing the effect of pitting. There is no protective slag present in steel and, consequently, when corrosion starts there is nothing to retard its progress and the result is a deep pit which, in a comparatively short time, tends to penetrate the wall of the pipe.

2. **Better Welding**—The efficiency of a weld is measured by the effectiveness of the union of metal to metal. When welding steel, the blacksmith uses borax as a flux to assist adhesion, but such fluxing is obviously impracticable in making pipe. On the other hand, the welding of wrought iron requires no addition of flux, the slag content making it self-fluxing. This explains why the weld in wrought iron pipe is more efficient than in steel. Crushing tests show that in 94 cases out of a hundred, the weld in Byers pipe is as strong or stronger than the body-metal.

3. **Threading**—The superior threading qualities of Byers pipe are due to the characteristic wrought iron fibrous structure, which causes the chips to break or crumble, thus reducing friction and preventing the chip space from clogging. The result is a clean, minutely accurate thread which will make a permanently strong, leak-proof joint. The inherent advantages of the metal, aided by the high standard of threading maintained in the Byers mills, makes for the utmost in strength, toughness, tightness and alignment of pipe joints.

4. **Resistance to Shocks and Vibration**—The fibrous nature of the iron enables Byers pipe to withstand shocks and vibration much better than steel, in spite of the slightly higher tensile strength of the latter. Figures for tensile strength, elastic limit and elongation are valueless as a criterion of endurance under vibratory stresses and repeated shocks.

Steel resembles glass in its characteristics and any minute fracture soon develops to failure when subjected to vibration, expansion, shocks and stresses. On the other hand, the slag in wrought iron arrests the progress of minute fissures before they can develop to appreciable size. Steel may further be likened in structure to a solid bar of metal, while wrought iron resembles stranded wire cable.

The ability of wrought iron to withstand severe shocks without fracturing is nowhere of greater importance than in mine service where falls of the roof are likely to occur, and in pumping and power plant service where there is more or less vibration. Experience has shown that wrought iron bends under repeated stresses while steel shatters.

Identification—Excepting only the smallest sizes, all Byers pipe has the Name and **Year of Manufacture** rolled in the iron every three or four feet as shown in the illustration.

Ask for Bulletin No. 26A, "What Is Wrought Iron?"; Bulletin No. 27, "The Experience of Practical Men"; Bulletin No. 30, "An Investigation of Pipe Corrosion"; Bulletin No. 32, "Corrosion of Cast Iron, Wrought Iron and Steel Pipe in House Drainage Systems"; Bulletin No. 38, "The Installation Cost of Pipe"; Bulletin No. 41, "Facts About Galvanized and Other Coated Pipe."

Specific cases, showing the life of wrought iron and steel pipe in service in and around mines, will be furnished upon request.

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THE DUFF MANUFACTURING CO.

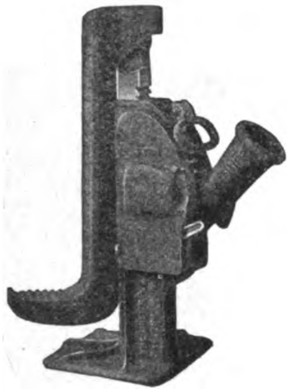
Main Office and Works
PITTSBURGH, PA.

New York—50 Church St.
Chicago—Peoples Gas Bldg.
Atlanta—Candler Bldg.
San Francisco—Monadnock Bldg.
Houston—Southern Pacific Bldg.
St. Louis—Railway Exchange Bldg.

Exclusive Manufacturers of

Duff and Barrett Jacks—Makers of High Grade Drop Forgings

Duff Emergency Jacks



A jack of wide adaptability in mines on account of the claw which grapples the load at almost any angle. Especially valuable for replacing locomotive or coal car in case of derailment.

Forged steel claw is hung on a ball and socket joint so that it is free to swivel sideways 120° (around the jack) and out from the base when the latter is set in an inclined position. This jack is single acting and the full rated capacity may be lifted on either the head or the claw.

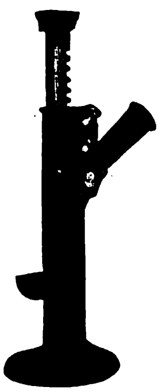
Jack No.	Capacity in Tons	Height of Top	Height of Toe	Raise Inches	Weight Pounds	Code Word	List Price
239	15	22"	3"	10½	110	Emcy	$55.00

Duff Screw Fittings for Timber Braces

These screw fittings are used for mine shaft work in connection with timber struts or braces, in any length from two to thirty feet. Easily put in place and removed. A few turns of the lever nut tightens the brace in position. Save much time and labor, and many dollars worth of lumber. When required they can be furnished with caps for the butt ends of the timbers; however, unless otherwise stated, all orders will be filled without butt end caps. Timbers are not furnished. Round washer plates without flanges can be furnished instead of square ones, when so ordered. In ordering, give diameter and length of screw and size of cap wanted.

Diam. of Screw Inches	Length of Screw Inches	Size of Cap or Washer Plate Inches	Weight per Dozen in Lbs.	Code Word	List Price per Dozen Sets	Butt End Caps per Dozen
1½	14	4x 4	175	Tack	$18.00	$ 3.00
1½	14	6x 6	192	Tag	20.00	4.00
1½	18	6x 6	214	Tank	22.00	4.00
2	18	6x 6	384	Tar	38.00	5.00
2	18	8x 8	410	Teak	40.00	7.00
2	18	10x10	450	Tenor	42.00	10.00
2	18	9x12	444	Tern	44.00	11.00

Duff Mine Jacks



Built especially for service in coal mines where it is necessary to have a jack of the very simplest design. Will not become clogged with fine rock, dirt or coal. Especially useful for handling coal-cutters. They contain only three simple operating parts, each part strong and positive in action, namely the machine cut steel rack, the socket lever and retaining pawl. These jacks may be lowered notch by notch when under the load or dropped instantly when free.

Jack No.	Cap. in Tons	Height Inches	Raise Inches	Weight with Lever	Code Word	List Price
226	2½	18½	10¼	31	Wool	$18.00
223	4	22	13	50	Wayne	25.00

No. 219

No. 2

No. 50

No. 3

No. 29

Duff Ratchet Jacks

These jacks are ratcheted up or down notch by notch, the direction being reversed by the shifting of the position of the reversing lever. Adapted for the rapid handling of mining machinery, motors, mine cars, light and narrow gauge track and all general lifting purposes. They are built of the very best materials and are as simple and perfect in construction as it is mechanically possible to make them. They represent manufacturing and engineering experience extending over a period of 38 years. Standing squarely behind the performance of every Duff Jack is the name and reputation of the largest jack manufacturers in the world.

Jack No.	Capacity in tons	Action	Height Inches	Raise Inches	Size Bar Inches	Weight Pounds	Code Word	List Price
50	5	double acting	16	8	1¼x1¼	35	King	16.00
51	5	double acting	21	13	1¼x1¼	42	Duke	18.00
18	10	single acting	21	10	1⅝x1⅝	75	Roge	25.00
2	10	double acting	21	10	1⅝x1⅝	70	Bote	25.00
3	12	double acting	26½	15	1¾x1⅞	100	Clmo	30.00
4	15	double acting	22	10	2 x2	106	Data	35.00
339	15	single acting	22	11½	2¼x1¾	87	Soak	40.00
219	15	single acting	28	17½	1¾x2¼	105	Seam	40.00
29	25	single acting	28	17	2½x2¼	190	Star	95.00

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INDIANA FOUNDRY COMPANY, Inc.

154 Clymer Ave., INDIANA, PA.

Heavy Heating Stoves

We have been specializing in the manufacture of plain, heavy Heating Stoves for over forty years. These years of experience have enabled us to work out a mix of iron which insures the longest possible service for the castings which make up these stoves. Each individual part is carefully designed and properly proportioned. Every stove is assembled at our plant before shipment is made, thus making sure of a perfect fit. Our stoves are fully guaranteed against defects in material or workmanship.

Round Top Dexter

	No. 4	No. 5	No. 6
Height	40″	46″	52″
Weight	220 lbs.	330 lbs.	500 lbs.
Diameter of Fire Bowl	16″	19″	22″
Size of Stove Pipe	6″	6″	7″

The Dexter Stove, in both the round top and flat top styles, is an old favorite, having been on the market for a great many years.

This stove is equipped with both basket and shaking grates. Being made in three different sizes, the purchaser can choose the proper size for the particular purpose in mind. Dexter Stoves are simple in design, and massive in construction. We do not hesitate to make the statement that there is no better plain, heavy heating stove on the market today than our Dexter.

Flat Top Dexter

	No. 4	No. 5	No. 6
Height	40″	46″	52″
Weight	220 lbs.	330 lbs.	500 lbs.
Diameter of Fire Bowl	16″	19″	22″
Size of Stove Pipe	6″	6″	7″

The stoves illustrated on this page show only four of the many different styles and sizes which make up our line. We have a stove to offer for every requirement, from the smallest to the largest. We will gladly send our illustrated stove catalog, which shows our entire line, upon request.

We are in position to furnish Caboose Stoves, Laundry Stoves (with one, two or four lids), School House and Church Stoves and Stoves for Shops, Factories, Railroad Stations, etc.

Flat Top Jumbo

"Jumbo" is one of the largest heating stoves on the market. This stove can be furnished with either round or flat top, as shown in the illustrations. Weight about 660 lbs., height 54″, diameter of fire bowl 23″, floor space required 32″x36″, smoke pipe 7″.

"Jumbo" Stoves are fitted with combination shaking and dumping grates, which permit the fire to be easily and quickly cleaned.

When we designed this stove, our idea was to place on the market a stove large enough to meet the most severe conditions, heavy enough to give the utmost in service, and yet to be neat and pleasing in general appearance. That we have been successful in carrying out this idea, is proved by the large number of Jumbo Stoves in actual use today.

Round Top Jumbo

Our Illustrated Stove Catalog, Which Describes in Detail Our Complete Line of Stoves, Will Be Gladly Sent Upon Request

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THE B. F. GOODRICH RUBBER CO.

BOSTON NEW YORK AKRON KANSAS CITY MINNEAPOLIS
CHICAGO DENVER SEATTLE

Goodrich
Hi-Press
Rubber Footwear

With the Red Line 'Round the Top

A very important feature of The B. F. Goodrich Rubber Company's Rubber Footwear Line is Boots and Shoes for the Miner. Every type used in mines is manufactured. They are the finest procurable—made of highest grade materials throughout, and embodying all the experience and rubber knowledge gained by Goodrich during the course of over half a century of manufacturing experience.

Numerous and rigid inspections insure the user footwear free from manufacturing defects and fully up to that standard which has brought Goodrich its reputation for high grade rubber goods throughout the entire world.

To insure your always obtaining genuine Goodrich Rubber Footwear each Goodrich boot and shoe has been marked by the Red Line 'Round the Top. This is your sure guide to long economical wear and comfort—a Goodrich pledge of quality and best effort.

White Short

White Hip

White Lehigh

SIXTY THOUSAND DEALERS SELL GOODRICH RUBBER FOOTWEAR

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COLONIAL SUPPLY CO.

217 Water Street

Bell Phones, 1042-1043-1044 Court. P. & A., 1870 Main.

PITTSBURGH, PA.

Branch Offices

New York 39-41 Cortlandt St. | Philadelphia 1001 Chestnut St. | Youngstown, Ohio 507 Stambaugh Bldg. | Wheeling, W. Va. 40 11th St.

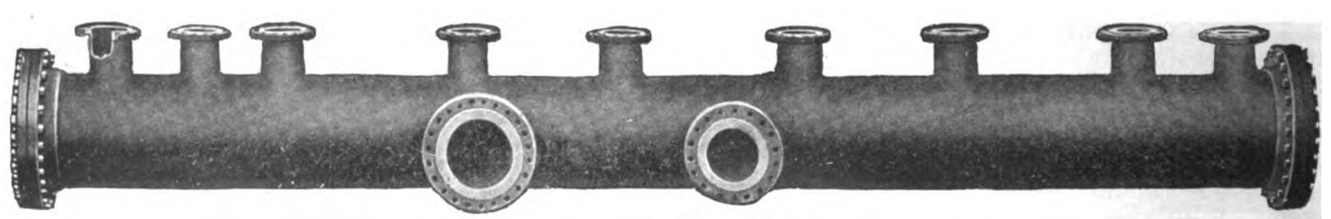
TRADERS EXPORTERS IMPORTERS

"Everything for the Mine"

Products

Abrasives
Anemometers
Anvils
Asbestos Goods
Augers
Automobile Supplies
Axles
Babbitts
Ball Bearing Hangers
Barrows
Barry Transmission Appliances
Bars—Steel and Iron
Bells
Belting
Benders
Bibbs
Bits—Mining Machine
Blacksmith Supplies
Blasting Machines
Blocks
Boilers
Boiler Tubes
Boiler Trimmings
Bolts
Brass Goods
Brattice
Brooms
Brushes
Buckets
Builders' Supplies
Burners
Cables
Cans
Cars
Carts
Castings
Cement
Chain
Chalk
Checks—Brass
Chemicals
Chucks
Clamps
Clips
Clocks
Cocks
Coke Oven Supplies
Contractors Supplies
Conveying Machinery
Copper
Cordage
Cots
Couplings
Drills
Duck
Dynamite
Electrical Supplies
Elevator Buckets
Emery
Emery Cloth
Emery Paper
Emery Wheels
Engineers' Supplies
Engines
Expanders
Extinguishers—Fire
Fans—Electric
Fans—Mine
Farriers' Tools
Fence
Fibre Pipe
Files
Filters
Fire Alarms
First Aid Supplies
Fittings
Flanges
Forgings
Forks
Foundry Supplies
Furnaces
Fuses
Gauges—All Kinds
Gaskets
Gas Supplies
Glass
Glue
Graphite
Greases
Grinders
Hack Saw Blades
Hammers
Handles
Hangers—Pipe
Hangers—Shaft
Hardware—All Kinds
Hatchets
Headlights
Heaters
High Speed Tools
Hitchings
Hoists
Hose—All Kinds
Hydrants
Hytempite Bonding Cement
Ice Tools
Indicators
Injectors
Inspirators
Instruments
Iron and Steel Products
Jackhammer Air Drills
Jacks—All Kinds
Karge Cushion System
Knives
Lace Leather
Lamps—Miners'
Ladders
Lanterns
Lathes
Lead Pipe, etc
Leather—All Kinds
Leather Belting
Lineman Supplies
Lubricators
Lumber
Machinery
Mattocks
Meters
Mine Supplies
Mine Tools
Mine Ventilation Equipment
Motors
Nails
Natural Gas Supplies
Nipples
Nuts
Oil Engines
Oilers
Oiling Devices
Oils
Oil Well Supplies
Packing—All Kinds
Pails
Paints
Paper
Picks—Clay, Coal and Puncher
Pillow Blocks—"S. K. F."
Pipe and Tubing—All Kinds
Pipe Fibre
Plates—Steel and Iron
Pliers
Plows
Plumbing Supplies
Pulleys
Pumps—All Kinds
Rags—Wiping
Rail Benders
Railroad Supplies
Ratchets
Rawhide
Reamers
Recording Gauges
Roofing—All Kinds
Rollers—Wood
Rope—All Kinds
Rope—Manila
Rope—Wire
Rosin
Rubber Goods of All Kinds
Safety First Supplies
Sand Paper
Salamanders
Sand Driers
Saws—All Kinds
Scales—All Kinds
Scraper Heads
Screw Plates
Separators
Shafting
Sheets—Steel
Shoes—Horse all kinds, Mule
Shovels
Signals
Signs
Sisal
S. K. F. Ball Bearing Hangers
Sledges
Smoothon
Spikes
Stable Fittings
Steam Traps
Steel Goods
Stocks and Dies
Stoves
Stucco Machine—Hodges Electric
Surveying Instruments
Switches
Tackles
Tanks—All Kinds
Tapes
Taps
Tents
Thermometers
Tools—All Kinds
Torches
Track Tools
Transmission Appliances
Trolleys
Trucks
Tubes
Tubing—All Kinds
Turnbuckles
Twine
Unions
Valves—All Kinds
Ventilators
Vises—All Kinds
Wagon Supplies
Washers
Waste—Cotton and Wool
Waste Cans
Wheelbarrows
Wheels
Whistles—Electric
Wire—All Kinds
Woodworkers' Tools
Wrenches—All Kinds

NAVCO POWER PIPING NAVCO



The welding Processes used to fabricate the "NAVCO" extra heavy pipe header here illustrated, and by the use of the "NAVCO" Square Lap Joints to connect it with the line and branches, reduces the liability of leakage to a minimum and eliminates many expensive flanged joints.

NAVCO

"EVERY INSTALLATION HELPS OUR REPUTATION."

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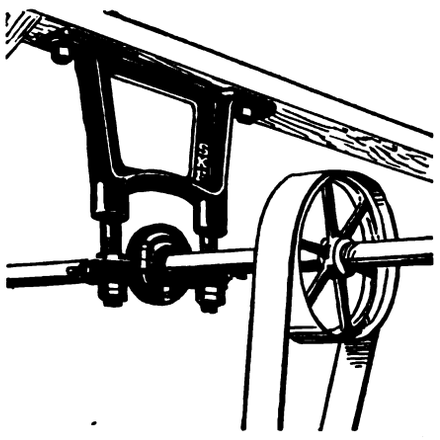
COLONIAL SUPPLY CO.

Our Engineering Department, consisting of Special Engineers, offers you free advice on Power Saving, Transmission Installations, Refractory Problems, Work Shop Equipments, Illumination and Equipment of Mines and Oil and Gas Engines.

SKF Ball Bearing Hangers and Pillow Blocks



Utilize all your power and maintain economical operation of line shaft equipment by installing SKF Self - Aligning Ball Bearing Hangers and Pillow Blocks. They cause the shaft to ride almost frictionless, not only when aligned, but under extreme conditions of misalignment. The inner race tilts with the shaft like a ball and socket joint and the bearing can never bind. Incidentally, they will save 80% of your oil bill, because they are sealed oil-tight by felts. Repairs and replacements are so infrequent as to be almost negligible.

Leather Belting

Especially adapted to Mine Use is Alexander Dreadnaut Leather Belting—Improved Waterproof—Impervious to water and moisture.

Barry Steel Split Pulley

Built for strength. Constructed entirely on the tubular plan combining great rigidity with extreme lightness. No rivets are used in its construction. It is electrically welded.

Made entirely of special steel and formed in accurately constructed dies.

Gives "Maximum Horse Power with Minimum Beltslip" and comes in both straight and crown face in all sizes. Crown face is always furnished unless straight is specified.

Colonial Black Gum Wood Mine Rollers

Guaranteed to give fifty percent increased efficiency of haulage lines, reduce maintenance cost, provide truer alignment of gudgeons, minimize roller and cable abrasion, do away with flat roller trouble and make a wonderful saving in power. Genuine Black Gum Wood used in their manufacture—no soft sweet or red gum—no tupelo or second grade black.

They are bored straight, the gudgeon cannot wear loose, the roller is true and smooth in its rotation and there is better protection afforded to steel cables, while the life of the roller is greatly prolonged.

Colonial Jackhammer Drills

The Newest and the Best, representing the highest efficiency, indestructiblity, simplified design and operation. Any size for any rock.

Anemometers

Genuine Birams Anemometers for registering Air Currents in Mines, Tunnels, Flues and Furnaces.

Colonial Babbitt Metal

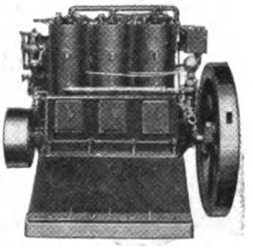
Just Fits the Ladle, Melts Quickly, Pours Uniformly, Very Hard, Stands Heavy Duty and Resists Wear. The Best Babbitt for General Service.

Royal Cotton and Wool Waste

Clean, Soft, Downy, Absorbent, Resilient. Clean and free from foreign substances.

Oil Engines

Fuel problems are removed and operating costs materially reduced by the installation of a "Wolverine" Stationary Oil and Producer Gas Engine. Owing to its extremely simple and strong design, this engine is ideal where reliable power is required without complicated mechanism. For driving small power plants, isolated machinery, electric lighting units, pumping purposes, and a multitude of other applications, this engine is a favorite power, because it is simple to install, cheap to run, easy to manage and above all, absolutely dependable. We have in stock Oil Engines from the smallest to the largest size.



Sluice Gates

Controlling Gates for Tunnels and Canals, Inlet and Outlet Gates for Filter Plants and every variety of service.

Pipe and Tubing

Factory inspected, carefully selected, pipe is an important factor in Colonial Pipe Service. A rigid standard of quality with a careful and prompt distribution helps us cut your maintenance costs.

Our stocks are complete with Wrought Iron and Steel Pipe, Wrought Iron and Steel Tubing, Wrought Iron and Steel Line Pipe, Lap Steel Welded Boiler Tubes, Lap Welded Charcoal Boiler Tubes, Pure Copper Boiler Tube Ferrules. Also Mild Open Hearth Lap Welded "Perfect" Seamless Cold or Hot Drawn Steel Tubes and Tyler Tubes.

Bermico Fibre Pipe for sulphur water and other acids. Wood Pipe in all sizes for all purposes.

Pipe of any size cut and threaded to your blue print or sketch.

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COLONIAL SUPPLY CO.

Duriron Acid Resisting Metal Products

Wherever in your plant there is acid to be combated Duriron is the metal to be used. It is being adopted by many chemical manufacturers and industrial plants because of its practically everlasting wear. Once installed, acids beat against it in vain.

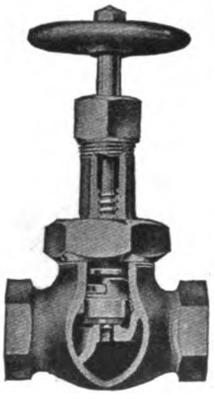
Among the many things now made of DURIRON are Drain Pipes, Ejectors, Fittings, Plug Cocks, Pressure Pipe, Pumps, Sheaves, Sinks, Valves and Wood Tank Connections.

Surveying Instruments

For accurate and rapid approximate surveys in ascertaining variations in gradients and levels in road making, railways, canals, water courses and in mining.

Colonial Brattice Cloth

Three grades of Non-Inflammable, Rot-Proof, Tear-Resisting and Long-Wearing Brattice. Made of Genuine Imported Jute.



Valves

Discriminating application of our valve knowledge to your needs by experienced engineers makes Colonial Service of superior value. Our stocks are large and complete, containing a valve for every possible working condition. Every Valve we handle has been selected for some specific purpose after thorough investigation of all makes. Our Valve Department is under the management of experienced engineers, who will gladly consult with you regarding your own valve installations.

Colonial Packing

Especially serviceable for Steam Piston, Ammonia and Hot Water Pumps. Made in Coil, Spiral or Ring form for high and low pressures.

M and M Rail Clamps

The Kind that Grips but Never Slips. Best in use for Cars on Grades, Loading Platforms, Under Tipples, Traveling Cranes and Car Stops on Air Ferries.

Flexipipe

A Flexible Air Tubing made from strong canvas, impregnated chemically to render waterproof and airtight. Carries a fresh supply of air from a fan or blower right against the face in drifts and shafts; eliminates lost time and lowers temperature.

Fire Prevention Apparatus

Our complete line of fire prevention apparatus includes the three-gallon soda and acid fire extinguisher, the one-quart ever ready hand pump extinguisher and so on up to large chemical engines.

The Colonial 3-Gallon Chemical Fire Extinguisher combines strength of construction, ease of operation, readiness at all times and absolute certainty of action with no hitches at critical moments. There is no hard-to-reach nook or corner that can escape its powerful stream of fire quenching soluton. Made of the best rolled 16 B. & S. Stubb gauge cold rolled copper, heavy brass castings and rail, ground joint, crimp brass ferrule, and 5-ply rubber hose instead of the cheaper 3-ply used by many extinguisher makers. The metal is non-corrosive. Weight 17½ lbs. empty—charged and ready for use it weighs 38 lbs. Capacity 3 gallons. Stream can be thrown a distance of 50 feet.

Tested by Underwriters' Laboratories (Inc.) under the direction of the National Board of Fire Underwriters.

"Ceag" Miners' Lamps

Made entirely of metal: There is no possibility of leakage and no danger of harm to men. No Alkaline used.

On account of using solidified electrolyte in its manufacture the lighting is uniform regardless of angle or position of the battery. All parts easily exchangeable.

Insulated Brush

Found most efficient for cleaning around switchboards, insulators and electrical equipment. Makes cleaning thorough and safeguards your men. Non-Conductor of electricity.

Linemen's Collapsible Tool Bag

Eliminate danger of tools falling to the ground and so being out of reach when wanted—or injuring persons below. Made with canvas sides and wooden bottom—no metal parts to come in contact with electric current.

Pocket Blasting Machine

Fires 5 shots at once. Operates by key in base. Built for hard use. Dust and moisture proof.

Corrugated Roofing

Strongest and most rigid of all forms of sheet metal roofing or siding. Easily and rapidly applied.

Colonial Rubber Roofing

Specify "Colonial" when ordering Rubber Roofing. It is not affected by acid conditions which abound in mine service and around coke ovens. Easily applied on either flat or steep surfaces. Contains no tar and has fire resisting qualities. It resists wear, wind and weather. Nails, cement and directions for laying packed in each roll.

Furnished in rolls 36 inches wide and 36 feet long, 108 square feet, or sufficient to cover one square roof surface.

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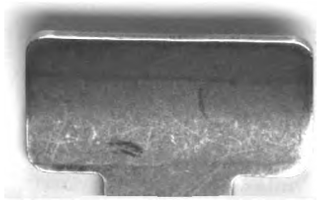

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